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**WATER QUALITY ASSESSMENT FOR THE PORTNEUF RIVER
TOTAL MAXIMUM DAILY LOAD PROGRAM**

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**WATER QUALITY ASSESSMENT FOR THE PORTNEUF RIVER
TOTAL MAXIMUM DAILY LOAD PROGRAM**

by

Mei Liu

A thesis

submitted in partial fulfillment

of the requirements for the degree of

Master of Science in the Department of Biology

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BIOGRAPHICAL SKETCH

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LIST OF SYMBOLS

A	= algal biomass concentration, mg/L
A_x	= cross-sectional area, m ²
BOD ₅	= 5-day BOD, mg/L
BOD _u	= ultimate BOD, mg/L
C	= concentration, mg/L
Chl a	= chlorophyll a concentration, mg/m ³
C _s	= DO saturation concentration, mg/L
d	= mean depth of the stream, m
DIS_P	= concentration of inorganic or dissolved phosphorus, mg-P/L
F ₁	= fraction of algal nitrogen uptake from ammonia pool, unitless
F _L	= algal growth limitation factor for light, unitless
F _N	= algal growth limitation factor for nitrogen, unitless
F _P	= algal growth limitation factor for phosphorus, unitless
D _L	= dispersion coefficient, m ² /s
D _m	= molecular diffusion coefficient, m ² /day
I	= surface light intensity, KJ/m ² -hr
I _z	= light intensity at a given depth (z), KJ/m ² -hr
K ₁	= carbonaceous deoxygenation rate constant, day ⁻¹
K ₂	= reaeration coefficient, day ⁻¹
K ₃	= rate of loss of BOD due to settling, day ⁻¹
K ₄	= benthic oxygen uptake, mg-O ₂ /m ² -day
K _{BOD}	= BOD conversion rate coefficient, day ⁻¹
K _L	= Michaelis-Menten half saturation coefficient for light, KJ/m ² min
K _N	= Michaelis-Menten half saturation constant for nitrogen, mg-N/L
K _P	= Michaelis-Menten half saturation constant for phosphorus, mg-P/L
KN_N	= Kjeldahl nitrogen, mg-N/L
L	= the concentration of ultimate carbonaceous BOD, mg/L
M	= mass, mg
N _e	= effective local concentration of available inorganic nitrogen, mg-N/L
NH4_N	= concentration of ammonia nitrogen, mg-N/L
NO23_N	= nitrite plus nitrate, total, mg-N/L

NO ₃ _N	= concentration of nitrate nitrogen, mg-N/L
NO ₂ _N	= concentration of nitrite nitrogen, mg-N/L
ON_N	= concentration of organic nitrogen, mg-N/L
OPHOS_P	= concentration of orthophosphate phosphorus, mg-P/L
ORG_P	= concentration of organic phosphorus, mg-P/L
O	= concentration of dissolved oxygen, mg/L
O'	= saturation concentration of dissolved oxygen at local temperature and pressure, mg/L
P _N	= algal preference factor for ammonia nitrogen, unitless
Q	= flow (m ³ /s)
s	= external source or sinks, mg/s
t	= time, s
TOT_P	= phosphorus, total, as P, mg/L
total P	= total phosphorus concentration, µg/L
u	= velocity, m/s
\bar{u}	= mean velocity, m/day
V	= A _x dx = incremental volume, m ³
x	= river distance, m
X _T	= value of the coefficient at the local temperature (T)
X ₂₀	= value of the coefficient at the standard temperature (20°C)
z	= depth variable, m

Greek symbols

α_0	= ratio of chlorophyll a to algal biomass, µg-Chl a /mg-A
α_1	= fraction of algal biomass that is nitrogen, mg-N/mg-A
α_2	= phosphorus content of algae, mg P/mg-A
α_3	= the rate of oxygen production per unit of algal photosynthesis, mg-O/mg-A
α_4	= the rate of oxygen uptake per unit of algae respired, mg-O/mg-A
α_5	= the rate of oxygen uptake per unit of ammonia nitrogen oxidation, mg-O/mg-N
α_6	= the rate of oxygen uptake per unit of nitrite nitrogen oxidation, mg-O/mg-N
β_1	= rate constant for the biological oxidation of NH ₃ to NO ₂ , day ⁻¹
β_2	= rate constant for the biological oxidation of NO ₂ to NO ₃ , day ⁻¹
β_3	= rate constant for the hydrolysis of organic nitrogen to

	ammonia, day ⁻¹
β_4	= rate constant for the decay of organic phosphorus to dissolved phosphorus, day ⁻¹
λ	= light extinction coefficient, m ⁻¹
λ_0	= non-algal light extinction coefficient, m ⁻¹
λ_1	= linear algal self-shading coefficient, m ⁻¹ /μg-Chla
λ_2	= nonlinear algal selfshading coefficient, m ⁻¹ /(μgChla/L) ^{2/3}
μ	= local specific growth rate of algae, day ⁻¹
μ_{max}	= maximum algal growth rate, day ⁻¹
θ	= temperature correction factor, unitless
ρ	= algal respiration rate, day ⁻¹
σ_1	= algal settling rate, m/day
σ_2	= benthos source rate for dissolved phosphorus, mg-P/m ² -day
σ_3	= benthos source rate for ammonia nitrogen, mg-N/m ² -day
σ_4	= organic nitrogen settling rate, day ⁻¹
σ_5	= organic phosphorus settling rate, day ⁻¹

ABSTRACT

Using QUAL2E-UNCAS, a one-dimensional, steady-state, water quality model was developed for the Portneuf River stretch (from 55.2 km to 13.5 km) to support the Portneuf River TMDL program waste load analysis (WLA). The model consists of 40 reaches and 482 computational elements, including 8 tributaries and 6 point sources.

The Portneuf River Model was calibrated using available flow and water quality data. The model simulated 13 water quality variables including temperature, BOD_5 , DO, algae, organic-N, ammonia-N, nitrite-N, nitrate-N, organic-P, dissolved-P, total-P, sodium, and chloride.

The modeling results indicate the following: (1) the present level of BOD_5 is not high enough to affect the DO level in the Portneuf River; (2) the numerous springs and groundwater discharges between Batiste Rd Bridge and Siphon Rd Bridge are the largest nitrate-N and total-P contributors to the river; and (3) Pocatello WPC is the largest ammonia-N contributor to the Portneuf River; however, Batiste Springs, undocumented springs, and groundwater discharges are the primary sources of nutrients and causes of eutrophication in the Lower Portneuf River.

Based on nutrient mass balance, (1) the ammonia-N loading from Pocatello WPC is estimated to be 95 kg N/day, which is considerably smaller

than the nitrate-N loading of 380 kg N/d; (2) the ammonia-N loading from Batiste Springs is estimated to be 66 kg N/day; and (3) the estimated nitrate-N and total phosphorus-P loadings from the undocumented springs and groundwater discharges are 1744 kg N/day and 839 kg P/day, respectively.

Based on the uncertainty analysis via Monte Carlo simulation, the number of Monte Carlo realizations of: (1) total inorganic nitrogen (as N) that occur exceeding the TMDL nutrient target of 0.3 mg/L is 100%; (2) ammonia-N that occur exceeding 0.3 mg/L is 72% at the junction of the Portneuf River and the WPC outfall, and 100% at the junction of the Portneuf River and Batiste; (3) total-P that occur exceeding the TMDL nutrient target of 0.075 mg/L is 100%; and (4) DO concentration that occur exceeding 6.0 mg/L is 100%.

The model simulations for the Pocatello WPC's hypothetical upgrade scenarios predict the following: (1) if Pocatello WPC was upgraded with an ideal nitrification or nitrification-denitrification process, ammonia-N concentration would decrease by 41% at the junction of the WPC outfall and the Portneuf River, and the nitrification-denitrification process would decrease nitrate-N concentration by 23%; (2) neither the nitrification nor the nitrification-denitrification process would affect the present level of eutrophication (i.e., growth of algae); (3) an ideal phosphorus removal process or nitrification-denitrification combined with phosphorus removal process would decrease organic-P by 33%, but give insignificant effects on dissolved-P, total-P, and the growth of algae.

CHAPTER I

INTRODUCTION

The Portneuf River is located in Southeastern Idaho. It originates from Chesterfield Reservoir, Bingham County, and terminates in American Falls Reservoir, Power County. The Portneuf River subbasin area is about 3520 km² (DEQ, 1999a). The Portneuf River watershed and water quality stations are shown in Figure 1.

The Portneuf River and its tributaries are affected significantly by human activities. Eighteen waterbodies in the Portneuf River are listed under Section 303(d) of the Clean Water Act (DEQ, 1999a). In addition to the main stem of the Portneuf River, other major tributaries on the list within the subbasin include Mink, Rapid, Marsh, Dempsey, Pebble, and Toponce Creeks. The pollutants on the 303(d) list are sediment, nutrients, bacteria, flow alteration, oil and grease, and dissolved oxygen (DEQ, 1999a). Among them, sediment and nutrients are the pollutants of most concern in the Portneuf River.

Section 303(d) also requires the states to determine the Total Maximum Daily Loads (TMDLs) for pollutants (Houck, 1999). A TMDL analysis is being performed for the Portneuf River. According to Curran (1999), "Simply stated, TMDLs represent an estimate of the capacity of a specific waterbody to

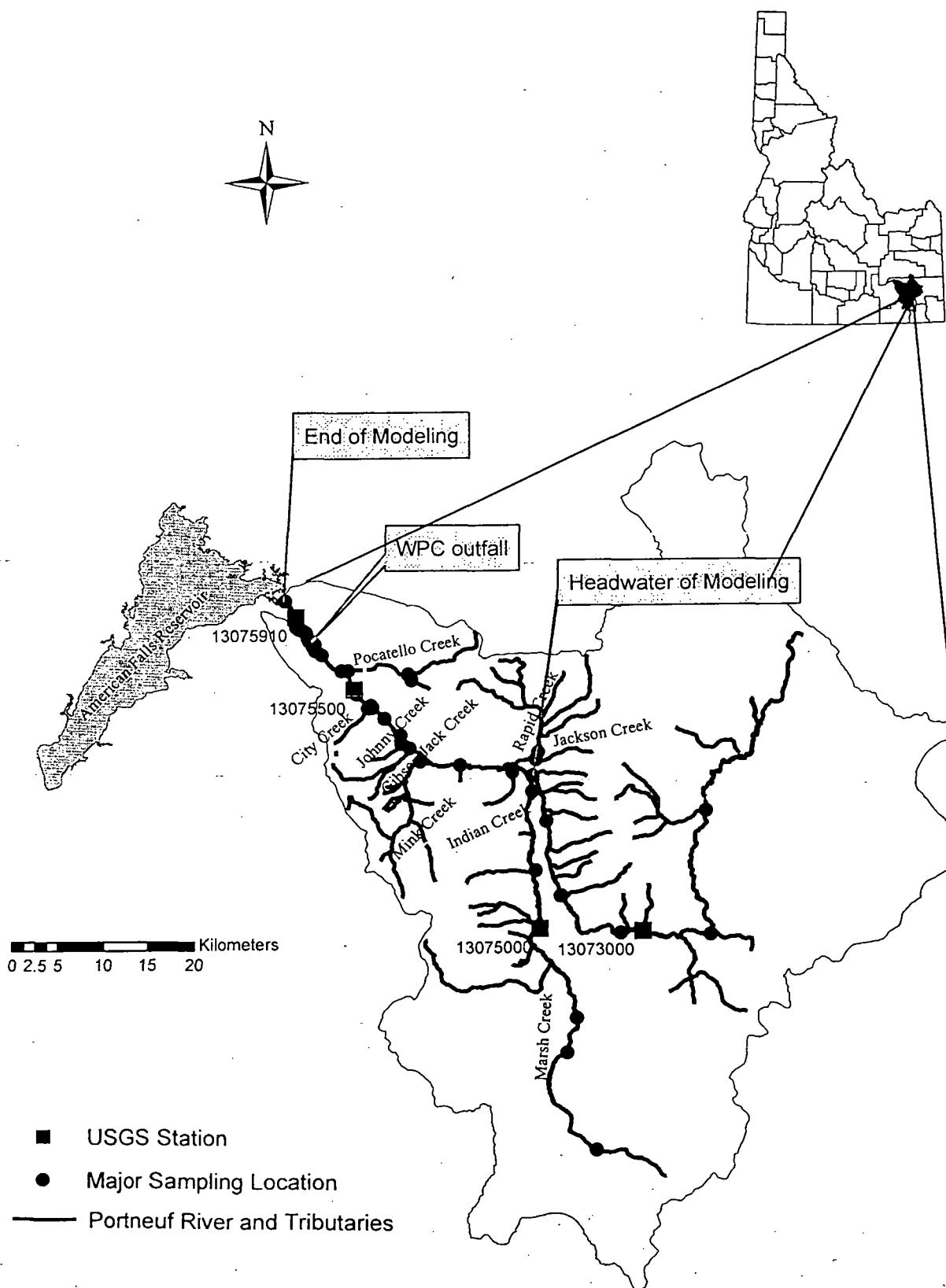


Fig. 1. The Portneuf River Watershed and Water Quality Stations

assimilate pollution and still achieve designated uses. " The overall process for a subbasin approach to TMDLs includes three steps: 1) subbasin assessment, 2) loading analysis, and 3) implementation plan(s) (DEQ, 1999b). The loading analysis (step 2) includes an estimate of a waterbody's pollutant load capacity, a margin of safety, and allocations of load to pollutant sources (DEQ, 1999b). One way to determine the load capacity is modeling (DEQ, 1999b).

The QUAL2E water quality model was chosen as the tool because it has been used for numerous applications, validated, and is well documented. QUAL2E is a one-dimensional stream water quality model that was developed by the U. S. Environmental Protection Agency (EPA). It can simulate up to 15 water quality constituents such as Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Ammonia as N, Nitrate as N, Organic Phosphorus as P, and conservative constituents (Brown and Barnwell, 1987). It can handle multiple waste discharges and tributary flows. QUAL2E is one of the most widely used surface water quality model for conventional pollutant impact evaluation (Brown and Barnwell, 1987). The application of QUAL2E for various river systems has been reported in America and Europe (Drolc and Koncan, 1996; Chaudhury et al., 1998).

The objectives of this study are: 1) to develop the water quality model for the Portneuf River by using QUAL2E; 2) to assess the impact of pollutants on the Portneuf River water quality; and 3) to quantify nutrients load to support the

Portneuf River TMDL program.

This modeling effort will be based on the Portneuf River water quality database that is being developed at Idaho State University (Rackow, 2002b). The data have been gathered from many sources including U.S. Geological Survey (USGS) station, Department of Environmental Quality (DEQ), the city of Pocatello, the elemental phosphorus plant (FMC), and others.

CHAPTER II

LITERATURE REVIEW

Water Resources

Surface Water and Groundwater. Norvitch and Larson (1970) investigated the water resources in the Portneuf River Basin, and reported that the sources of water supply to the Portneuf River basin are precipitation and underflow from adjacent basins. There is recharge and discharge between the river and groundwater. The major use of water is for irrigation, followed by municipal, industrial, domestic, and stock use (Norvitch and Larson, 1970). Chen (2001) measured the stream flow (July 29–August 5, 2000) along the Portneuf River. He reported that the flow variations are resulted from the interaction between groundwater and surface water, artificial diversions, and tributary discharges.

Springs. There are numerous springs along the Portneuf River. Many springs in the mountainous areas are intermittent (Norvitch and Larson, 1970). Perry et al. (1990) studied 27 springs along the lower part of the river. Batiste Spring is a large spring (approximately $1.27 \text{ m}^3/\text{s}$) that is located on the west bank of the Portneuf River nearly opposite the Pocatello Water Pollution Control Plant (WPC) (DEQ, 1989). The other major spring is Papoose Springs with a total

discharge of approximately 0.86 m³/s (DEQ, 1989). Figure 2 shows the estimated flow of the lower Portneuf River during a low-flow condition (DEQ, 1989). As is seen, the springs that exist between the WPC Plant and Siphon Road Bridge are the major sources of the Portneuf's flow during summer minimum flows.

Water Quality

Sediments. The upper Portneuf River (from its source to Marsh Creek) has been designated as a stream segment which is severely impacted by sediment from non-irrigated cropland (Drewes, 1987). The main problems of the lower Portneuf River (from Marsh Creek to the mouth) are sediments and nutrients resulting from stream bank erosion and agriculture runoff (Perry et al., 1977). Marsh Creek is the major tributary of the Portneuf River affecting the Portneuf River water quality, particularly Total Solids (TS) and Fecal Coliform (FC) bacteria (Perry et al., 1977). Study by Chen (2001) indicated that the high turbidity in Marsh Creek was produced by soil erosion caused by farming and grazing.

Nitrogen. DEQ (1989) documented an exceedance of state water quality standards for un-ionized ammonia in the Portneuf River below the Pocatello WPC's effluent discharge outfall. Data from the city of Pocatello (2001) show that Batiste Springs add high dissolved nitrogen to the river. The average concentration of nitrite plus nitrate (measured as nitrogen) was 3.65 mg/L in the

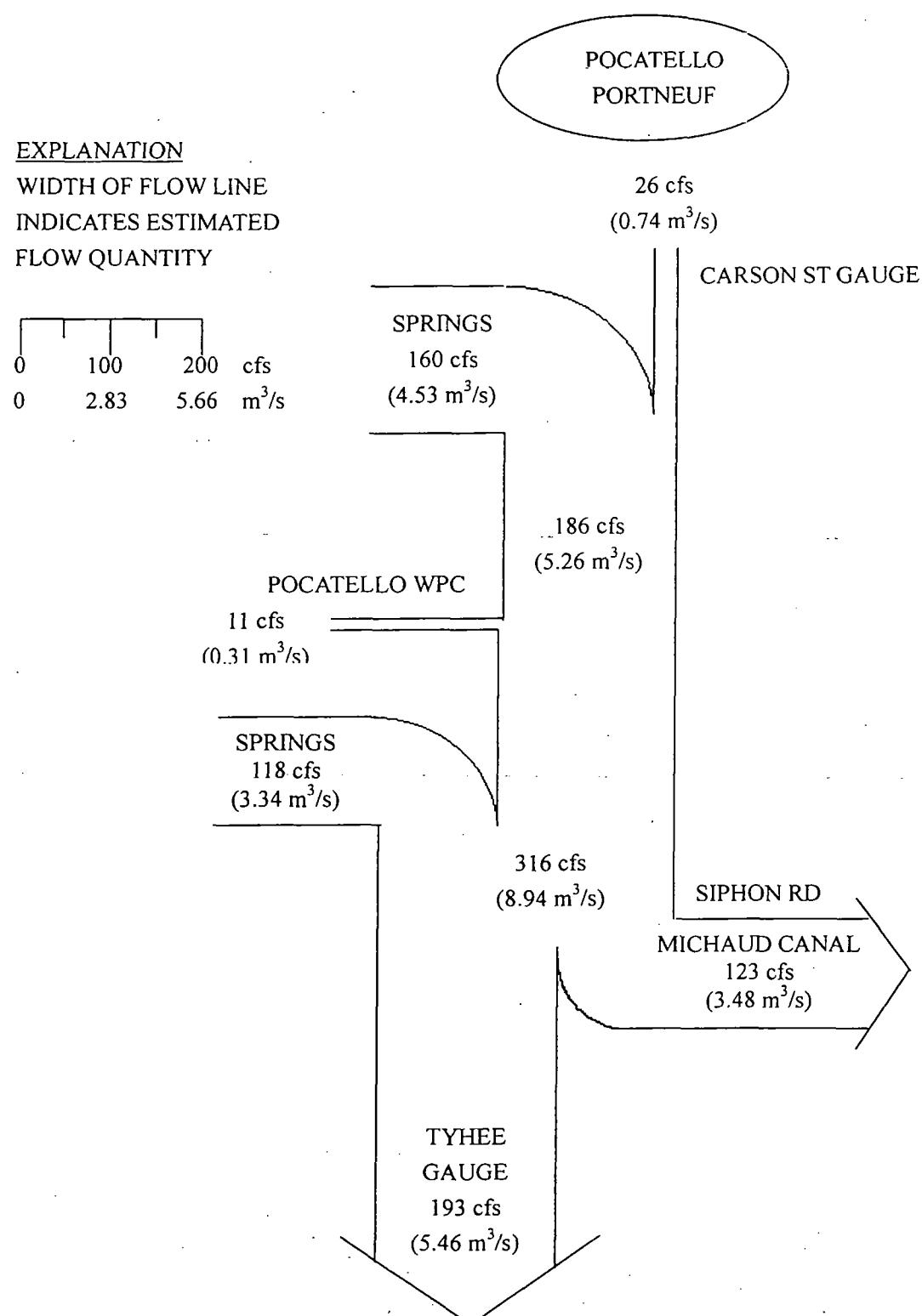


Fig. 2. Estimated Flow Quantity (m^3/s) of the Lower Portneuf River on September 1, 1988 (DEQ, 1989)

period of 1999 to 2001 (the city of Pocatello, 2001). Mink Creek monitoring data showed that the total nitrate levels ranged from 0.2 to 0.7 mg/L for the November 1997 to August 1998 period (DEQ, 1999a).

Phosphorus. The total phosphorus concentration in the WPC discharge was reported as high as 8.2 mg/L (Perry et al., 1977) and 8.3 mg/L (EPA, 2001). The effluents from the elemental phosphorus plant (FMC) and J. R. Simplot fertilizer plant were believed to cause a rise in phosphorus concentrations in the lower Portneuf River (Perry et al., 1977). The reported average P concentrations in the effluent of the two plants (9.96 mg/L for FMC and 65.43 mg/L for Simplot) were very high in relation to the river concentrations (Perry et al., 1977). The J. R. Simplot's outfall is currently treated in the Pocatello WPC; thus, the discharge canal is obsolete. Pocatello FMC Plant was closed in 2001. Total phosphorus in Mink Creek reached 0.2 mg/L in April 1998, exceeded the level of 0.1 mg/L suggested by EPA (DEQ, 1999a). Rapid Creek, Jackson Creek, and Indian Creek were also reported to have high total phosphorus concentrations in 1986 (Drewes, 1987).

U.S. Environmental Protection Agency (EPA) suggested that total phosphorus not exceed a concentration of 0.1 mg/L for prevention of nuisance aquatic growth in streams or flowing waters (DEQ, 1999a). Phosphorus is an essential nutrient for plant growth and is often the limiting agent. It plays the key role for eutrophication in lakes and streams (Correll, 1998). Thus the effluents

with high concentrations of phosphorus and the springs cause the eutrophication in the slow moving parts of the Portneuf River and the American Falls Reservoir (Campbell et al., 1992).

Pocatello Storm Drains. The storm drainage system of the city of Pocatello to the Portneuf River is about 3237.5 km² (DEQ, 1980). The research by Idaho State Division of Environment (DEQ, 1980) indicated that the levels of suspended solids, total solids, Chemical Oxygen Demand (COD) are very high, and dissolved minerals (copper, iron, lead, and zinc) exceeded the EPA water quality criteria for freshwater aquatic life.

QUAL2E Model

Historical Background. QUAL-I was initially developed by the Texas Water Development Board in the 1960s (Brown and Barnwell, 1987). It was written in ANSI FORTRAN 77. EPA improved and developed several versions of the model. After extensive review and testing, the QUAL-II series became one of the most widely used water quality models (Brown and Barnwell, 1987).
QUAL2E- UNCAS is an enhancement to QUAL2E that allows the modeler to perform uncertainty analysis on steady-state water quality simulations (Brown and Barnwell, 1987). Based on DOS version, QUAL2E Windows™ interface was developed to be as user-friendly as possible to assist the user in data input and model execution. The Windows interface was developed for the U.S. EPA's

Office of Science and Technology, Standards and Applied Science Division, to help the Division implement the TMDL program (EPA, 1995).

Application. QUAL2E is widely used as a water quality planning tool, such as to study the impact of waste loads on stream water quality, to develop waste load allocations, and to evaluate alternate water quality management strategies. Many studies reported the successful calibration, validation, and application of QUAL2E. For example, the Blackstone River model (Chaudhury et al., 1998) and the Red River model (Wesolowski, 1994) showed that QUAL2E successfully simulated DO and nutrients profiles. Further study of the impact of the Woonsocket wastewater treatment plant to the Blackstone River by QUAL2E indicated that the violation of DO criteria of 5.0 mg/L downstream to the wastewater treatment plant was caused by the instream nitrification due to the high ammonia from this facility (Chaudhury et al., 1998). Wesolowski applied the model to various combinations of three hypothetical waste loads and two streamflows. Drolc and Koncan (1996) used QUAL2E as a tool to predict DO concentration at different flows in the River Sava in Slovenia. The case study of Contentnea Creek by Little and Williams (1992) focused on the calibration of QUAL2E.

Limitation. One of the most important assumptions in QUAL2E is that the major transport mechanisms, advection and dispersion, are significant only along the main direction of flow (Brown and Barnwell, 1987). QUAL2E can handle

multiple waste discharges, withdraws, tributary flows, and incremental inflow and outflow. It limits the headwater elements to a maximum of 10, junction elements to 9, point source and withdrawal elements to 50 (EPA, 1995). QUAL2E is typically used as a steady-state model. The forcing functions (such as flow and waste loads) are considered to be constant in the model (EPA, 1995). It may be inappropriate for some types of simulations, such as the pulse-input loads. Case study by Walton and Webb. (1994) showed that the solution for pulse loads by using QUAL2E model had significant numerical dispersion.

TMDL Program

Introduction. According to DEQ (1999b), "Total maximum daily load (TMDL) simply is the sum of the individual waste load allocations (WLAs), load allocations (LAs), natural background, and a margin of safety (MOS)." The required elements of a TMDL project, include: waterbody name and location, existing pollutant load, sources, wasteload allocation (load allocated to point sources), load allocation (load allocated to nonpoint sources and background loads), margin of safety, allowance for reasonably foreseeable future growth, and Implementation plan.

TMDLs have been required by the Clean Water Act since 1972. It is important for the approach of using standards to protect water quality, and provides the technical support for water quality control (DEQ, 1999b). The

process for developing a TMDL involves: 1) identifying the desired water quality objective and the pollutant, or combination of pollutants, 2) determining the maximum load of the pollutant that can be allowed, 3) allocating the total maximum load to the various point sources and nonpoint sources (Curran, 1999).

The Portneuf River TMDL Program. According to DEQ (1999c), the Portneuf River TMDL is a two-phase implementation program. Phase I will be finished in 2004, and Phase II will end in Dec 2009. The tasks include basin assessment, loading assessment, monitoring, control measures, watershed analysis/modeling, and use attainability analysis.

The point sources that are identified for the Portneuf River TMDL program include the Pocatello WPC Plant, City of Pocatello Urban Runoff, FMC, Simplot, and small municipalities. Short-term and long term control strategies for these point sources have been reported by DEQ (1999c). For example, the short-term strategies for WPC Plant include a new \$7 million nitrification facility, and a continued monitoring program (DEQ, 1999c).

The pollutants listed in the Portneuf River TMDL include sediment, nutrients, bacteria, flow alteration, oil and grease, and Dissolved Oxygen (DO) (DEQ, 1999a). Among those pollutants, QUAL2E can simulate DO and the nutrients. Table1 summarized the state standards and TMDL targets for DO and nutrients (DEQ, 1999a).

Table 1. Summary of DO, and Nutrients for the Portneuf River TMDL

Pollutant's Name	Standards	Problems	Target
Nutrients	Un-ionized ammonia – not to exceed criteria for cold water biota and salmonid spawning. * Excess nutrients- surface waters of the state shall be free from excess nutrients that can cause visible slime growths or other nuisance aquatic growths impairing designated beneficial uses. *	The entire Portneuf River from Chesterfield Reservoir to American Falls Reservoir has nutrients listed as a pollutant	Nitrogen not to exceed 0.3 mg/L of nitrogen as total inorganic nitrogen Phosphorus not to exceed 0.075mg/L of phosphorus as total phosphorus
Dissolved Oxygen	Cold water biota- minimum of 6.0 mg/L. *	Hawkins Reservoir has DO listed as a pollutant	Insufficient data to develop a loading analysis

Note: * Source: IDAPA58.01.02 (2001).

CHAPTER III

MODEL DESCRIPTION

Introduction

The stream flow and mass balance are computed by QUAL2E for each computational element. The user defines the length of each element. For each element QUAL2E considers: 1) inflow at the upstream end of the element; 2) outflow at the downstream end of the element; 3) inputs and withdrawals of the element; and 4) the reaction of each water quality constituent (Brown and Barnwell, 1987).

The basic equation solved in QUAL2E is a one-dimensional advection-dispersion mass transport equation. This equation includes the effects of advection, dispersion, dilution, constituent reactions and interactions, and sources and sinks (Brown and Barnwell, 1987). For any constituent, C, it can be written as:

$$\frac{\partial M}{\partial t} = \frac{\partial (A_x D_L \frac{\partial C}{\partial x})}{\partial x} dx - \frac{\partial (A_x u C)}{\partial x} dx + V \frac{dC}{dt} + s \quad (1)$$

where M = mass; t = time; A_x = cross-sectional area; D_L = dispersion coefficient; C = concentration; x = river distance; u = velocity; V = incremental volume and s = external source or sinks. Because M=VC, then,

$$\frac{\partial M}{\partial t} = V \frac{\partial C}{\partial t} + C \frac{\partial V}{\partial t} \quad (2)$$

Assume at steady state, $\partial Q/\partial t = 0$, then, $\partial V/\partial t = 0$. The equation (1) becomes,

$$\frac{\partial C}{\partial t} = \frac{\partial(A_x D_L \frac{\partial C}{\partial x})}{A_x \partial x} - \frac{\partial(A_x u C)}{A_x \partial x} + \frac{dC}{dt} + \frac{s}{V} \quad (3)$$

QUAL2E can simulate up to 15 water quality constituents. The C in equation (3) can be DO, BOD, temperature, algae as chlorophyll *a*, phosphorus cycle (organic and dissolved), nitrogen cycle (organic, ammonia, nitrite, nitrate), coliforms, arbitrary non conservative constituent, and three conservative constituents. For the Portneuf River Modeling, we selected DO, BOD, temperature, algae, phosphorus cycle, nitrogen cycle, and two conservative constituents (i.e., sodium and chloride).

Reach Identification and River Distance Data

The first step in modeling using QUAL2E is to subdivide the stream system into reaches, which have uniform hydraulic characteristics (e.g., stream slope, channel cross section, roughness) and the same biological rate constants (e.g., BOD decay rate, benthic source rates, algae settling rates). Each reach is then divided into computational elements of the same length (Brown and Barnwell,

1987). In this study, the chosen length of the computational element (Δx) was 0.1 km. The headwater of the model was determined at river distance 55.2 km (the

mouth of the Portneuf River at American Falls reservoir is defined as 0 km by USGS). The total length of the Portneuf River model was 48.2 km including the length of eight tributaries (6.5 km). The total computational elements were 482; i.e., 48.2 km/0.1 km (Appendix A).

QUAL2E allows tributary flows, multiple waste discharges, withdrawals, and incremental inflow and outflow. Eight creeks were taken into account in the Portneuf River model including Marsh Creek, Rapid Creek, Indian Creek, Mink Creek, Gibson Jack Creek, Johnny Creek, City Creek, and Pocatello Creek (Appendix A). Because the available data for Mink Creek, Gibson Jack Creek, Johnny Creek, and City Creek were taken at the mouth, only a 0.2 km stretch for each creek was modeled.

QUAL2E has some dimensional limitations. Table 2 summarizes the limitations and the values used in the Portneuf River model.

Table 2. Reaches and Elements Limitations of QUAL2E and those Assigned for the Portneuf River Model

	Model Limitations	The Model
Reaches	50	40
Total computational elements	500	482
Computational elements per reach	20	19
Headwater elements	10	9
Junction elements	9	8
Input and withdrawal elements	50	6

Hydraulics Data

Discharge. The "Portneuf River Database" is being developed by College of Engineering, Idaho State University (Rackow, 2002b). The database served as the major source of the water quality data, although available data are insufficient for robust modeling. The data were collected either from a single sampling event or from different time periods. The time intervals could be months or years.

More than thirty years' average monthly flow data from USGS gauge station and the database (Table 3 and Figure 3) indicate that the lowest flows occur in summer (July-September). It is most likely that high temperatures and the low flows in summer give a worst case scenario in modeling water quality of the Portneuf River. The flow data of September was used in the model calibration because the data sets in September 2000 were relatively complete.

Hydraulic characteristics. According to the QUAL2E manual (Brown and Barnwell, 1987), velocity (u) and depth (d) of the stream segment is determined by equations of the form:

$$u = aQ^b \quad (4)$$

$$d = \alpha Q^\beta \quad (5)$$

where Q = flow rate ; a , b , α and β = empirical constants. Two methods were used to obtain those constants in the model. One was determined from stage-discharge rating curves. It was used for the main stream (except reach 1,

Table 3. More than 30 Years' Average Monthly Flow Data
of the Portneuf River

Month	Average Monthly Flow (m^3/s)			
	USGS13075000	USGS13073000	DATABASE	USGS13075500
1	2.37	4.90	8.87	9.30
2	3.48	4.40	5.56	8.35
3	3.32	6.20	10.88	14.03
4	3.00	8.46	8.97	13.82
5	3.61	12.39	13.20	25.69
6	2.34	8.55	6.31	9.28
7	1.44	5.76	2.74	2.74
8	1.70	5.19	3.78	3.16
9	2.07	4.18	4.62	4.38
10	2.16	3.37	5.85	6.03
11	2.36	4.52	7.34	7.93
12	2.34	4.05	7.26	7.83

Note: USGS13075000, 13073000, and 13075500 locations
can be found in Figure 1.

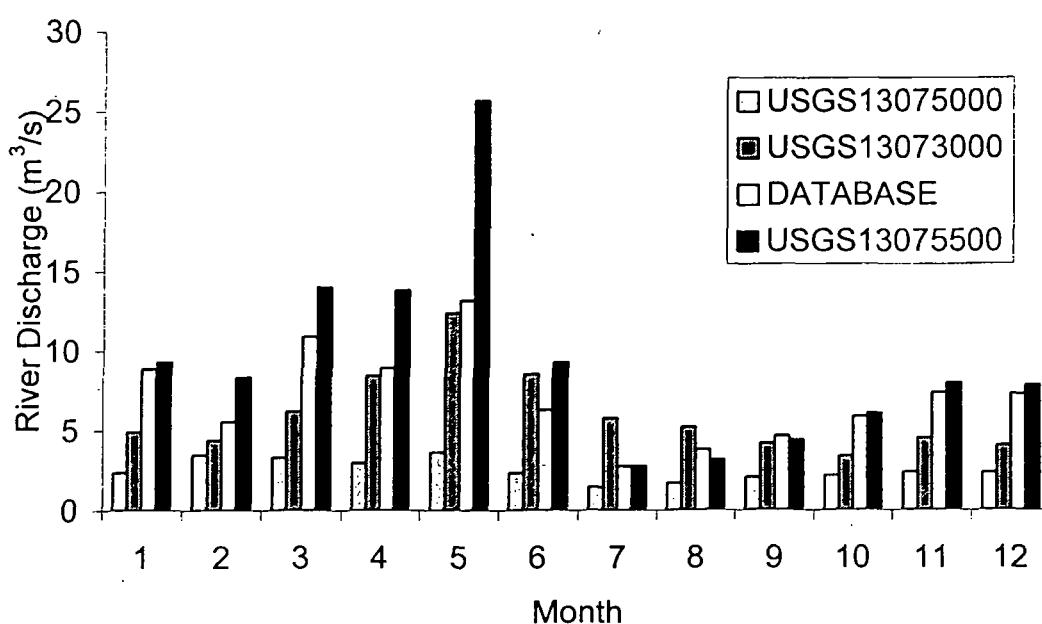


Fig. 3. More than 30 Years' Average Monthly Flow Data of the
Portneuf River

3, 6 and 8-13), Marsh Creek and Pocatello Creek. The equations are shown in Table 4.

The second method used the certain values of "b" and β to calculate "a" and α . According to Leopold et al. (1964), for "Ephemeral streams in semiarid United States", $b=0.34$ and $\beta=0.36$. Constants "a" and α of Reach 1, 3, 6 and 8-13 of the Portneuf River and six creeks were calculated by equations (4) and (5). The results are shown in Table 5.

There is a 2.4 km long rectangular concrete channel in the Portneuf River (from river distance 31.1 to 28.7 km) (US Army, 1992). The channel was divided into two reaches due to facilitate the large slope change at Custer Street Bridge. The equations are shown in Table 4.

Manning roughness coefficient (n) and dispersion constant (K) were provided in the QUAL2E manual (Brown and Barnwell, 1987). Table 6 shows the hydraulic characteristics data used in the modeling of the Portneuf River.

Major assumptions applied in the modeling are as follows:

1. Reach 34-40 (from Siphon Rd Bridge to the last reach of the modeling)
 $\beta=0$, because QUAL2E does not allow the negative β value (equation is in Table 4).
2. The constants a , b , α and β of Reaches 15, 16, 18, 20, and 21 are the same as that of Reach 22 and 23.
3. The constants a , b , α , and β of Reaches 3, 6, and 8-13 are the same as that of Reach 1.

Table 4. Equations of u and d for Reaches of the Portneuf River and Creeks

Stream	Site_ID	River_km	u	R ²	d	R ²
Portneuf River*	Wagon Wheel	33.3	$u=0.2583Q^{0.482}$	0.8407	$d=0.5999Q^{0.1551}$	0.7268
Portneuf River*	Concrete Channel above Custer Street Bridge	31.1	$u=0.6339Q^{0.3854}$	0.9999	$d=0.1294Q^{0.6146}$	0.9999
Portneuf River*	Concrete Channel below Custer Street Bridge	30.3	$u=0.7572Q^{0.3854}$	0.9999	$d=0.1083Q^{0.6146}$	0.9999
Portneuf River*	Carson Gage USGS13075500	28.5	$u=0.4302Q^{0.2649}$	0.7325	$d=0.2122Q^{0.5671}$	0.9311
Portneuf River*	Kraft Bridge	25.9	$u=0.1071Q^{0.6719}$	0.7804	$d=0.7022Q^{0.2617}$	0.4918
Portneuf River*	Batiste Rd Bridge	21.5	$u=0.4351Q^{0.3763}$	0.6655	$d=0.2076Q^{0.3758}$	0.6982
Portneuf River*	Siphon Rd Bridge	17.8	$u=0.0322Q^{0.8608}$	0.9584	$d=1.7302Q^{-0.0183}$	0.0058
Marsh Creek**	USGS13075000	53.3	$u=0.4026Q^{0.2912}$	0.1987	$d=3.0631Q^{0.4429}$	0.4301
Pocatello Creek**		26.8	$u=0.5861Q^{0.1341}$	0.77	$d=0.4932Q^{0.2269}$	0.7119

Note: * Source: Rackow (2002a).

** Appendix C.

Table 5. Values of a and α used for the Reaches of the Portneuf River and Creeks

Stream	River Distance(km)	Width (m)	Depth (m)	Velocity (m/s)	Flow (m ³ /s)	a	α
Portneuf River at Inkom	51.5	10.36	0.83	0.19	1.223	0.1774	0.7720
Rapid Creek	51.5	1.20	0.12	0.29	0.0418	0.8535	0.3763
Indian Creek	50.7	1.00	0.06	0.28	0.0168	1.1234	0.2612
Portneuf River at Fort Mine Rd	41.5	7.92	0.35	0.42	1.036	0.4150	0.3456
Mink Creek	40.0	1.95	0.165	0.44	0.147	0.8444	0.3290
Gibson Jack Creek	37.6	1.20	0.2	0.3	0.072	0.7339	0.5157
Johnny Creek	36.7	0.12	0.06	0.190	0.00137	1.7876	0.6441
City Creek	30.9	0.45	0.09	0.39	0.0176	1.5402	0.3854

Note: Flow, width, depth, and velocity data were from Chen (2001).

Table 6. Hydraulic Characteristics Used in Modeling of the Portneuf River

Reach No.	Dispersion Const.(K)	a	b	α	β	Manning Coeff.(n)
1	200	0.177	0.34	0.772	0.36	0.075
2	200	0.403	0.291	3.063	0.443	0.075
3	200	0.177	0.34	0.772	0.36	0.075
4	200	0.854	0.34	0.376	0.36	0.075
5	200	0.854	0.34	0.376	0.36	0.075
6	200	0.177	0.34	0.772	0.36	0.075
7	200	1.123	0.34	0.261	0.36	0.075
8	200	0.415	0.34	0.346	0.36	0.075
9	200	0.415	0.34	0.346	0.36	0.075
10	200	0.415	0.34	0.346	0.36	0.075
11	200	0.415	0.34	0.346	0.36	0.075
12	200	0.415	0.34	0.346	0.36	0.075
13	200	0.415	0.34	0.346	0.36	0.075
14	200	0.845	0.34	0.329	0.36	0.075
15	200	0.258	0.482	0.6	0.155	0.075
16	200	0.258	0.482	0.6	0.155	0.075
17	200	0.734	0.34	0.516	0.36	0.075
18	200	0.258	0.482	0.6	0.155	0.075
19	200	1.788	0.34	0.644	0.36	0.075
20	200	0.258	0.482	0.6	0.155	0.075
21	200	0.258	0.482	0.6	0.155	0.075
22	200	0.258	0.482	0.6	0.155	0.075
23	200	0.258	0.482	0.6	0.155	0.075
24	200	0.634	0.385	0.129	0.615	0.015
25	200	1.542	0.34	0.386	0.36	0.075
26	200	0.634	0.385	0.129	0.615	0.015
27	200	0.757	0.385	0.108	0.615	0.015
28	200	0.43	0.265	0.212	0.567	0.075
29	200	0.586	0.134	0.493	0.227	0.075
30	200	0.107	0.672	0.702	0.262	0.075
31	200	0.107	0.672	0.702	0.262	0.075
32	200	0.435	0.376	0.208	0.376	0.075
33	200	0.435	0.376	0.208	0.376	0.075
34	200	0.032	0.861	1.73	0	0.075
35	200	0.032	0.861	1.73	0	0.075
36	200	0.032	0.861	1.73	0	0.075
37	200	0.032	0.861	1.73	0	0.075
38	200	0.032	0.861	1.73	0	0.075
39	200	0.032	0.861	1.73	0	0.075
40	200	0.032	0.861	1.73	0	0.075

Geographical and Climatological Data

Geographical and climatological data were used in the model to calibrate DO concentration and to calculate the heat balance for simulating temperature. The "Global values" option was used in the model. With this option, QUAL2E assumes that the single values specified by the user will apply to all reaches in the system. These data are shown in Table 7.

Water Quality Data

Most water quality data, including water temperature, BOD_5 , DO, algae as chlorophyll a, organic nitrogen, ammonia nitrogen, nitrite nitrogen, nitrate nitrogen, organic phosphorus, dissolved phosphorus, sodium, and chloride, are from the "Portneuf Database" (Rackow, 2002b). Other sources include but are not limited to, various documents prepared by the City of Pocatello, EPA, and DEQ, Perry et al. (1990), and Chen (2001). The summer water quality data (July to September) (Appendix E) were selected in order to be consistent with the summer flow data and to calibrate the model.

Water Temperature. The values of the reaction coefficients in the source and sink terms were corrected for the temperatures calculated by the model. The temperature correction equation is:

$$X_T = X_{20} \theta^{(T-20)} \quad (6)$$

Table 7. Summary of Geographical and Climatological Data Used
in the Modeling

		Range in QUAL2E	Model Input
Geographical	Latitude(deg)		42
	Longitude(deg)		112.5
	Standard Maridian (deg)		105
	Basin Elevation (m)		1350
Climatological	Dust Attenuation Coeff. *	0.05-0.15	0.05
	Evaporation Coeff.		
	AE((m/hr)/mbar) *	0.0 - 9.1E-5	0.00009
	BE((m/hr)/mbar-m/s) *	0.2E-5 - 0.2E-4	0.00002
	Cloud***		0.396
	Wind Speed (m/s)***		4.17
	Dry Bulb Temperature **		34.44
	Wet Bulb Temperature **		16.11
	Barometric Pressure(mbar)***		1007

Note: * empirical constants, user can adjust them within the range.

**Source: Premier Industries, Inc.

***Source: Monthly average report. Average of summer data
(July- September)

where X_T = value of the coefficient at the local temperature; X_{20} = value of the coefficient at the standard temperature (20°C); and θ = temperature correction factor, and can be specified by the user. Table 8 summarized the default values provided in the QUAL2E manual and the values used in the modeling.

BOD₅. QUAL2E assumes that the deoxygenation of ultimate carbonaceous BOD (L) in the stream is a first order reaction (Brown and Barnwell, 1987). The BOD function is described as,

$$\frac{dL}{dt} = -K_1 L - K_3 L \quad (7)$$

where K_1 = carbonaceous deoxygenation rate constant (day^{-1}); and K_3 = rate of loss of BOD due to settling (day^{-1}). Because available BOD data were reported as BOD₅, BOD₅ values were chosen for the BOD input and output. QUAL2E converts BOD₅ to ultimate BOD (BOD_u) using equation (8)

$$BOD_u = \frac{BOD_s}{(1 - e^{s * K_{BOD}})} \quad (8)$$

where K_{BOD} = BOD conversion rate coefficient. K_{BOD} of 0.23 was used in the modeling.

DO. The DO balance in QUAL2E takes into account the reaeration of the stream, other internal sources of oxygen, and sinks of oxygen (Brown and Barnwell, 1987). The other sources include the photosynthesis and the oxygen contained in the incoming flow. The sinks are biochemical oxidation of carbonaceous and nitrogenous organic matter, benthic oxygen demand, and the

Table 8. The Comparison of θ value in QUAL2E and the Model

Rate Coefficient	X_T	Unit	QUAL2E Default Value	Model Value**
BOD Decay	K_1	day ⁻¹	1.047	1.047
BOD Settling	K_3	day ⁻¹	1.024	1.024
Reaeration	K_2	day ⁻¹	1.024	1.024
SOD Uptake	K_4	g•m ⁻² day ⁻¹	1.060	1.083*
Organic N decay	β_3	day ⁻¹	1.047	1.083*
Organic N Settling	σ_4	day ⁻¹	1.024	1.047*
Ammonia Decay	β_1	day ⁻¹	1.083	1.047*
Ammonia Source	σ_3	g•m ⁻² day ⁻¹	1.074	1.074
Nitrite Decay	β_2	day ⁻¹	1.047	1.047
Organic P Decay	β_4	day ⁻¹	1.047	1.047
Organic P Settling	σ_5	day ⁻¹	1.024	1.024
Dissolved P Source	σ_2	g•m ⁻² day ⁻¹	1.074	1.047*
Algal Growth	μ	day ⁻¹	1.047	1.024*
Algal Respiration	ρ	day ⁻¹	1.047	1.047
Algal Settling	σ_1	day ⁻¹	1.024	1.047*

Note: * Adjusted during the effort of calibration.

** Value used in this Portneuf River modeling.

oxygen utilized by algae respiration (Brown and Barnwell, 1987). The equation for the rate of change of oxygen is,

$$\frac{dO}{dt} = K_2(O^* - O) + (\alpha_3\mu - \alpha_4\rho)A - K_1L - K_4/d - \alpha_5\beta_1NH_4^-N - \alpha_6\beta_2NO_2^-N \quad (9)$$

where O = concentration of dissolved oxygen (mg/L); O^* = saturation concentration of dissolved oxygen (mg/L) at local temperature and pressure; K_2 = reaeration coefficient (day^{-1}); K_4 = benthic oxygen uptake ($\text{mg-O/m}^2\text{-day}$); α_3 = the rate of oxygen production per unit of algal photosynthesis (mg-O/mg-A), α_4 = the rate of oxygen uptake per unit of algae respiration (mg-O/mg-A); α_5 = the rate of oxygen uptake per unit of ammonia nitrogen oxidation (mg-O/mg-N); α_6 = the rate of oxygen uptake per unit of nitrite nitrogen oxidation (mg-O/mg-N); β_1 = rate constant for the biological oxidation of NH_3 to NO_2 (day^{-1}); β_2 = rate constant for the biological oxidation of NO_2 to NO_3 (day^{-1}); μ = local specific growth rate of algae (day^{-1}); and ρ = algal respiration rate (day^{-1}).

There are seven options to calculate the reaeration coefficient K_2 in QUAL2E. O'Connor and Dobbins equation (Option 3) was selected for the model based on stream velocity (\bar{u}) and depth (d) of the river. The equation is,

$$K_2^{20} = \frac{(D_m \bar{u})^{0.5}}{d^{1.50}} \quad (10)$$

where

$$D_m = 177.44 \times (1.037)^{T-20} \quad (11)$$

D_m = molecular diffusion coefficient (m^2 /day); and 177.44 = empirical constant.

Nitrogen. The nitrogen cycle in QUAL2E contains four components, organic-N, ammonia-N, nitrite-N, and nitrate-N (Brown and Barnwell, 1987). The equations governing transformations of nitrogen from one form to another are as follows.

For organic nitrogen (ON_N),

$$\frac{dON_N}{dt} = \alpha_1 \rho A - \beta_3 ON_N - \sigma_4 ON_N \quad (12)$$

where α_1 = fraction of algal biomass that is nitrogen (mg-N/mg-A); β_3 = rate constant for the hydrolysis of organic nitrogen to ammonia (day^{-1}); and σ_4 = organic nitrogen settling rate (day^{-1}).

For ammonia nitrogen (NH4_N),

$$\frac{dNH4_N}{dt} = \beta_3 ON_N - \beta_1 NH4_N + \sigma_3 / d - F_1 \alpha_1 \mu A \quad (13)$$

where

$$F_1 = P_N NH4_N / (P_N NH4_N + (1 - P_N) NO3_N) \quad (14)$$

where NO3_N = concentration of nitrate nitrogen; P_N = algal preference factor for ammonia nitrogen; and σ_3 = benthos source rate for ammonia nitrogen ($mg-N/m^2-day$).

For nitrite nitrogen (NO2_N),

$$\frac{dNO2_N}{dt} = \beta_1 NH4_N - \beta_2 NO2_N \quad (15)$$

For nitrate nitrogen,

$$\frac{dNO3_N}{dt} = \beta_2 NO2_N - (1 - F_1) \alpha_1 \mu A \quad (16)$$

Because organic nitrogen data were not found in the current "Portneuf Database" (Rackow, 2002b), the organic nitrogen concentration (ON_N) was estimated using equation (17).

$$ON_N = KN_N - NH4_N \quad (17)$$

Only very few nitrite data were found in the database. The nitrite-N concentration (NO2_N) was estimated using equation (18),

$$NO2_N = NO23_N - NO3_N \quad (18)$$

The relationship between nitrate nitrogen plus nitrite nitrogen (NO23_N) and nitrate nitrogen (NO3_N) was developed by plotting available data from the database (see Appendix D). Figure 4 shows the NO3_N vs. NO23_N plots. The relationship is given as

$$NO3_N = 1.0126 \times NO23_N - 0.0256 \quad (19)$$

The R² of 0.9989 suggests a very good correlation. Equation (19), however, can only be used when NO23_N is within the range of 0.025 to 2.03 mg/L.

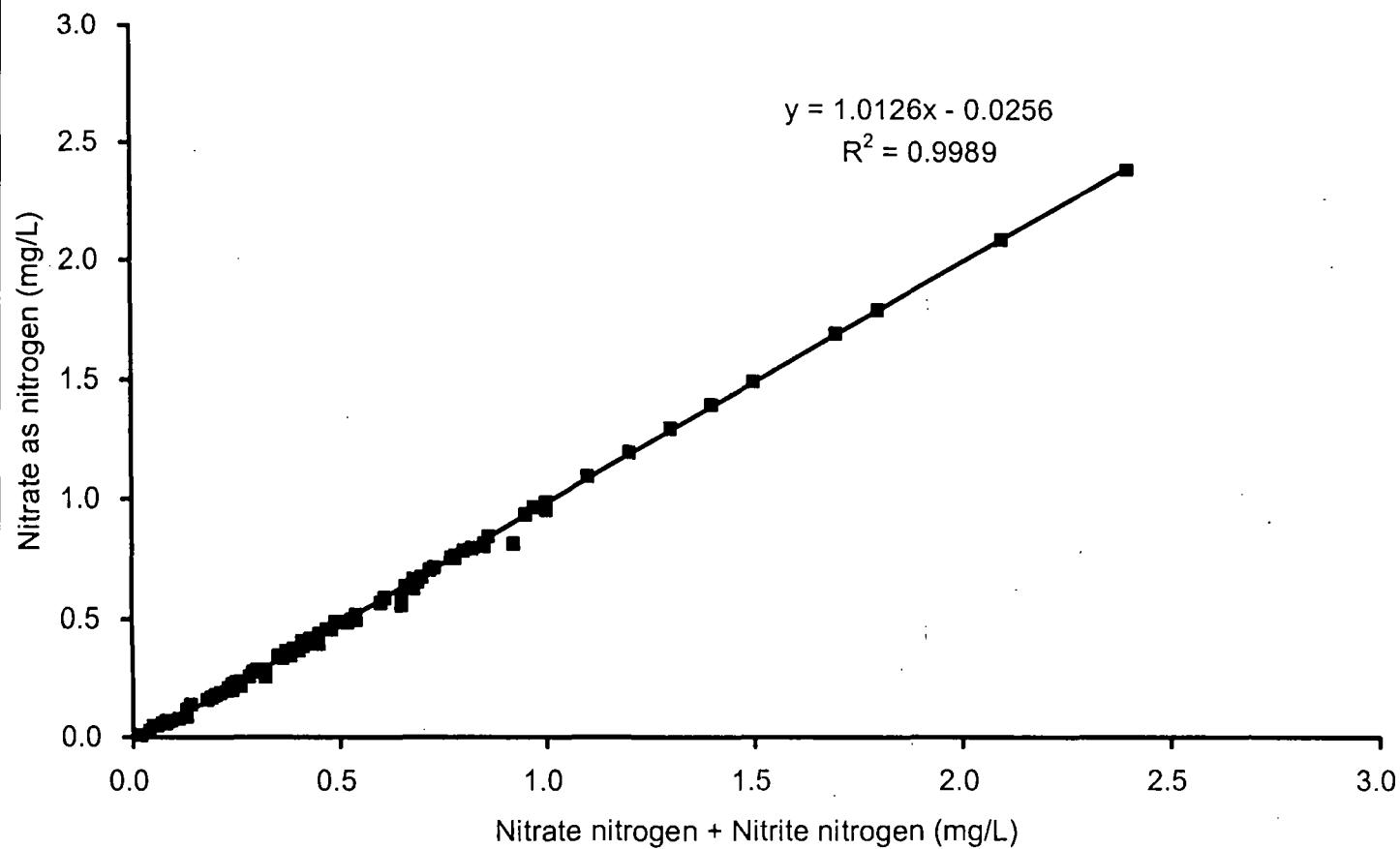


Fig. 4. Relationship between the Measured Concentration of Total Nitrate as Nitrogen and Total Nitrite + Nitrate as nitrogen.

Phosphorus. QUAL2E requires inputs of dissolved and organic phosphorus to simulate the interactions between them (Brown and Barnwell, 1987). The equations governing transformations of phosphorus from one form to another are:

For organic phosphorus (ORG_P),

$$\frac{dORG_P}{dt} = \alpha_2 \rho A - \beta_4 ORG_P - \sigma_5 ORG_P \quad (20)$$

where α_2 = phosphorus content of algae (mg P/mg-A); β_4 = rate constant for the decay of organic phosphorus to dissolved phosphorus (day⁻¹); and σ_5 = organic phosphorus settling rate (day⁻¹).

For dissolved phosphorus (DIS_P),

$$\frac{dDIS_P}{dt} = \beta_4 ORG_P + \sigma_2 / d - \alpha_2 \mu A \quad (21)$$

where σ_2 = benthos source rate for dissolved phosphorus (mg-P/m²-day).

There are insufficient data for organic phosphorus and dissolved phosphorus in the "Portneuf Database" (Rackow, 2002b). Although there is a discrepancy between them, orthophosphate phosphorus (OPHOS_P) is considered to be equal to dissolved phosphorus (DIS_P). Therefore, the organic phosphorus (ORG_P) is calculated by

$$ORG_P = TOT_P - OPHOS_P \quad (22)$$

The relationship between orthophosphate phosphorus (OPHOS_P) and total phosphorus (TOT_P) data obtained from the database (Appendix D) was shown in Figure 5, linear regression of the data yields

$$OPHOS_P = TOT_P \times 0.526 - 0.0474 \quad (23)$$

with R^2 of 0.6698. The equation can only be used when TOT_P is great than 0.09 mg/L; otherwise, OPHOS_P will be negative.

Chlorophyll a. In the QUAL2E model, phytoplankton concentration (algal biomass) is expressed by chlorophyll a (chl a). The conversion equation between algal biomass and chlorophyll a is

$$Chl \text{ } a = \alpha_0 A \quad (24)$$

where α_0 = ratio of chlorophyll a to algal biomass ($\mu\text{g-Chl a}/\text{mg-A}$); and A = algal biomass concentration (mg/L).

The differential equation that governs the growth and production of algae (chlorophyll a) is (Brown and Barnwell, 1987):

$$\frac{dA}{dt} = \mu A - \rho A - \frac{\sigma_1}{d} A \quad (25)$$

where σ_1 = algal settling rate (m/day). The local specific growth rate of algae (μ) is known to be coupled to the availability of required nutrients (nitrogen and phosphorus) and light (Brown and Barnwell, 1987). There are three options in QUAL2E for expressing multiple nutrient-light limitations on algal growth rate. In this modeling effort, the multiplicative option was used. This option represents the effects of nitrogen, phosphorus, and light that are multiplied together to determine their net effect on the local algal growth rate.

The algal growth rate is expressed as

$$\mu = \mu_{\max} (F_L)(F_N)(F_P) \quad (26)$$

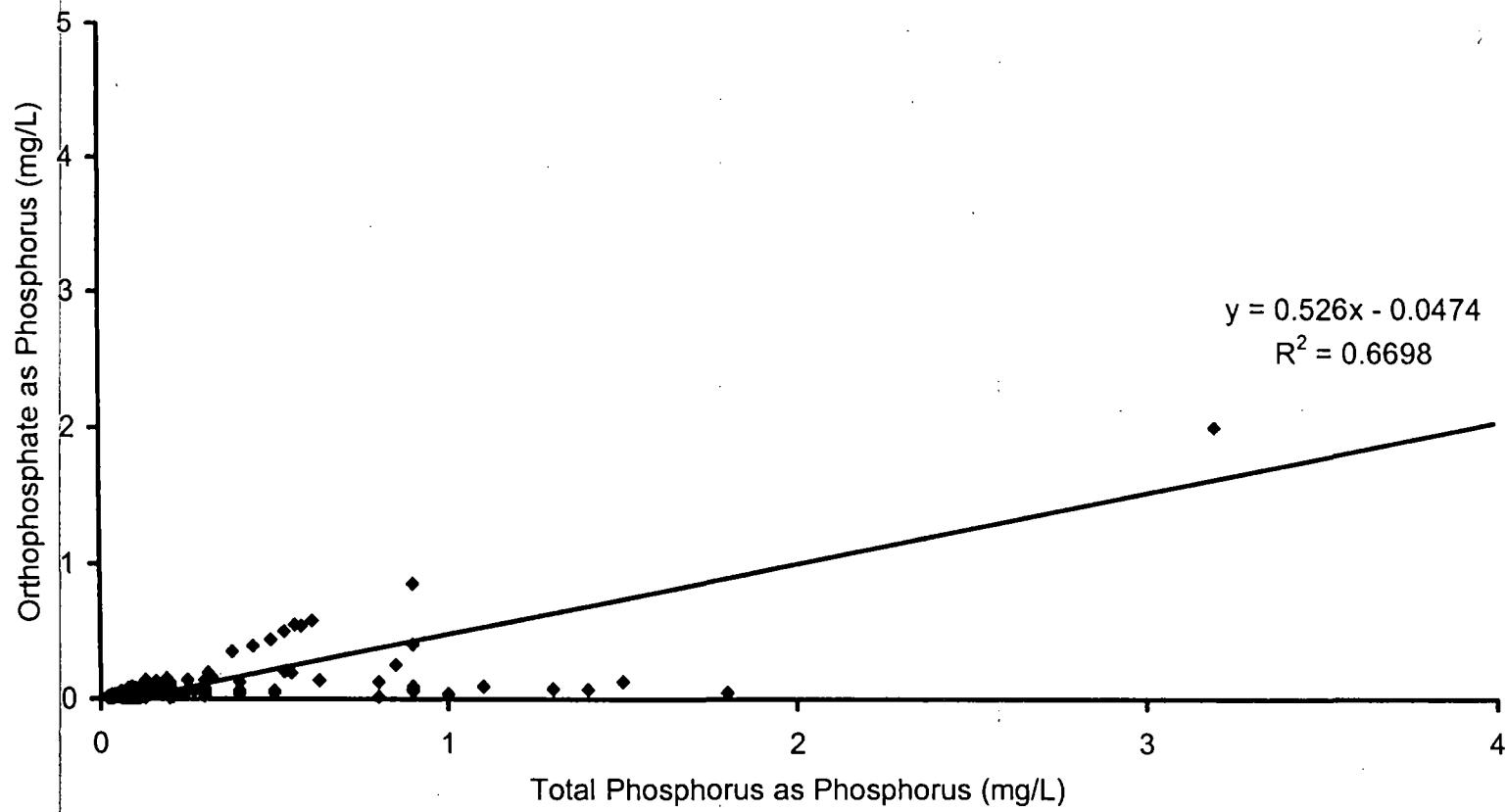


Fig. 5. Relationship between Measured Total Phosphorus as P and Orthophosphate as P

where F_L = algal growth limitation factor for light (unitless); F_N = algal growth limitation factor for nitrogen (unitless); and F_P = algal growth limitation factor for phosphorus (unitless).

Light-limiting algal growth has been extensively investigated (Zison et al., 1978). Half Saturation was chosen from three light function options that QUAL2E provides (Brown and Barnwell, 1987):

$$F_L = \frac{I_z}{K_L + I_z} \quad (27)$$

where I_z = light intensity at a given depth (z) (m); and K_L = Michaelis-Menten half saturation coefficient for light (KJ/ m^2 min). I_z is described as a function of I and λ . The equations are

$$I_z = I \exp(-\lambda z) \quad (28)$$

$$\lambda = \lambda_0 + \lambda_1 \alpha_0 A + \lambda_2 (\alpha_0 A)^{2/3} \quad (29)$$

where I = surface light intensity (KJ/ m^2 -hr); λ = light extinction coefficient (m^{-1}); λ_0 = non-algal light extinction coefficient (m^{-1}); λ_1 = linear algal self-shading coefficient ($m^{-1}/\mu g\text{-Chl } a$); and λ_2 = nonlinear algal selfshading coefficient ($m^{-1}/(\mu g\text{ Chla/L})^{2/3}$).

The algal growth limitation factors for nitrogen (F_N) and phosphorus (F_P) are defined by the Monod expressions (Brown and Barnwell, 1987):

$$F_N = \frac{N_e}{N_e + K_N} \quad (30)$$

$$F_P = \frac{P_2}{P_2 + K_P} \quad (31)$$

where N_e = effective local concentration of available inorganic nitrogen

(mg-N/L); K_N = Michaelis-Menten half saturation constant for nitrogen (mg-N/L); and K_P = Michaelis-Menten half saturation constant for phosphorus (mg-P/L). Ammonia and/or nitrate are assumed to be the source of inorganic nitrogen for algae. Then

$$N_e = NH_4 - N + NO_3 - N \quad (32)$$

There is no measured chlorophyll a data for the Portneuf River.

Chlorophyll a was determined by the average concentration calculated by the following three empirical equations (Appendix E):

Schnoor (1996):

$$\log (Chl_a) = -1.09 + 1.46 \log (\text{total } P) \quad (33)$$

Chapra (1997):

$$\log (Chl_a) = -0.259 + 0.76 \log (\text{total } P) \quad (34)$$

Chapra (1997):

$$\log (Chl_a) = -0.194 + 0.807 \log (\text{total } P) \quad (35)$$

Conservative elements. Sodium (Na) and chloride (Cl) were chosen as conservative elements that QUAL2E can simulate. The primary source of Na and Cl data is Chen (2001). Some data are from the "Portneuf River Database" (Rackow, 2002). The rest are calculated by the mass balance:

$$CQ = \sum C_i Q_i \quad (36)$$

For example, the sodium concentration of the model headwater was calculated as follows. In the Portneuf River at Inkom, $C=36.8 \text{ mg/L}$, $Q=1.2227 \text{ m}^3/\text{s}$; in Marsh Creek, $C_1=38.7 \text{ mg/L}$, $Q_1=0.9653 \text{ m}^3/\text{s}$; in Rapid Creek,

$C_2=13.2 \text{ mg/L}$, $Q_2=0.0418 \text{ m}^3/\text{s}$, where C_i and Q_i are the sodium concentration and flow, respectively, at each tributary. The Na concentration of the headwater of the model is,

$$C_3 = \frac{CQ - C_1Q_1 - C_2Q_2}{Q_3} = \frac{36.8 \times 1.2227 - 38.7 \times 0.9653 - 13.2 \times 0.0418}{0.2156} = 32.87 \text{ mg/L}$$

where $Q_3 = 0.2156 \text{ m}^3/\text{s}$.

Coefficients

As shown above, there are many reaction rate coefficients and system parameters in QUAL2E. Because of the lack of data to determine these coefficient values, the values were determined by the model calibration within the range recommended by the QUAL2E user's manual (Brown and Barnwell, 1987). Table 9 lists the recommended range and selected values for the Portneuf River modeling.

Table 9. Range of Reaction Coefficients in QUAL2E and the values in the Portneuf River model

Variable	Range *	Model Input **	Temperature Dependent	Variable by reach
α_0	10-100	41.25***	No	Yes
α_1	0.07-0.09	0.085	No	No
α_2	0.01-0.02	0.014	No	No
α_3	1.4-1.8	1.4	No	No
α_4	1.6-2.3	2.3	No	No
α_5	3.0-4.0	3.43	No	No
α_6	1.00-1.14	1.14	No	No
μ_{max}	1.0-3.0	1.5	No	No
ρ	0.05-0.5	0.10	No	No
K_L	0.02-0.10	0.03	No	No
K_N	0.01-0.30	0.2	No	No
K_P	0.001-0.05	0.03	No	No
λ_0	Variable	0.07	No	No
λ_1	0.002-0.02	0.0246	No	No
λ_2	0.0165 (Riley)	0.0165	No	No
P_N	0.0-1.0	0.5	No	No
σ_1	0.5-6.0	0.5	Yes	Yes
σ_2	Variable	5.78	Yes	Yes
σ_3	Variable	5.78	Yes	Yes
σ_4	0-10	1	Yes	Yes
σ_5	0-10	1	Yes	Yes
K_1	0.02-3.4	1.047	Yes	Yes
K_2	0.0-100		Yes	Yes
K_3	0-10	1.047	Yes	Yes
K_4	Variable	5	Yes	Yes
β_1	0.10-1.00	0.54	Yes	Yes
β_2	0-10	8	Yes	Yes
β_3	0-10	1	Yes	Yes
β_4	0-10	1	Yes	Yes

Note: * Brown and Barnwell, 1987.

** Coefficient value selected for the Portneuf River modeling.

*** 41 were selected for reaches 1-34, 25 for reaches 35-40.

CHAPTER IV

MODEL CALIBRATION

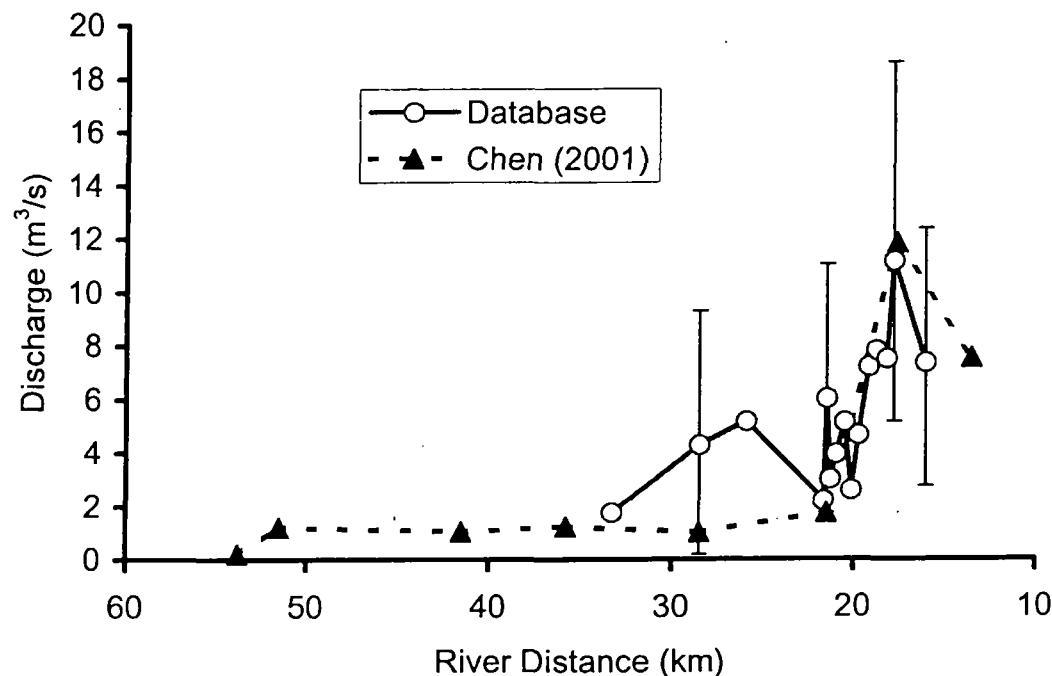
The model was calibrated in the steady-state mode. The data set of September 13, 2000 (Site_ID T-1 to T-10, Appendix B), and average summer data of other samplings (July- September) were used to calibrate the model. The adjustments were made to various reaction coefficients until simulated output matched the measured data. Some reaction coefficients were modified by reaches, and others were kept uniform in the entire reaches (Table 9).

Discharge

Discharge is an important component of the mass balance computation. Summer discharge data from the "Portneuf Database" (Rackow, 2002b), and July-August discharge data from Chen (2001) showed the similar change in flow rate along the Portneuf River (Figure 6 and Appendix E). Many springs or groundwater discharge into the Portneuf River from Batiste Bridge (21.5 km) to Siphon Bridge (17.8 km). The considerable amount of discharge occurs from springs (Figure 2), including Batiste Springs System, Papoose Spring System, Swanson Road Spring System, and Eastside Spring System (Perry et al., 1990).

Perry et al. (1990) investigated water quality of 27 springs, however, there may be more uncounted springs.

a) Discharge Data from River Distance 55.2 km to 13.5 km



b) Discharge Data from River Distance 22 km to 13.5 km

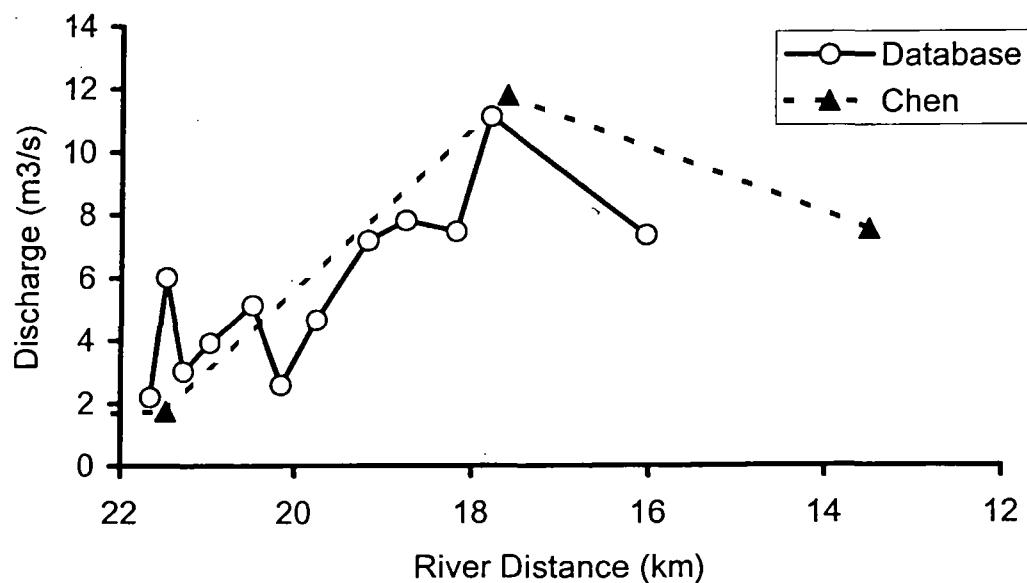


Fig. 6. Comparisons of Discharge Data Obtained from "The Portneuf Database" (Rackow, 2002b) and the Field Data Gathered by Chen (2001).
The error bar indicates a range.

Estimated Discharges. To calibrate the model, measured data on September 13, 2000 were used (Table 10). Although there may be an interchange between the river and groundwater above Batiste Springs Trout Farm discharge near Pocatello, the data of T-6 (20.2km, $Q=2.60\text{m}^3/\text{s}$) was excluded. The data at Kraft Road Bridge (25.9 km, $Q=5.16\text{m}^3/\text{s}$) was also excluded due to the big gap of discharge between T-1 (21.7km, $Q=2.20\text{m}^3/\text{s}$) and the uncertainty of single sampling data (July 20, 1999). The flow data for headwaters and point sources are shown in the Table 11. The single sampling data for Rapid Creek, Indian Creek, Mink Creek, Gibson Jack Creek, Johnny Creek and City Creek reported by Chen (2001) were used in this modeling.

Incremental Inflow. QUAL2E allows the input of the additional flows that are not represented by point source inflows or headwaters. These inflows, such as groundwater discharges, are assumed to be uniformly distributed over the reach. After calculating the water balance, eight reaches (from reach 30 to reach 37) were considered to have incremental inflows. The estimated flow data are presented in Table 11. The simulated discharge and measured data are shown in Figure 7.

Table 10. Measured Discharge Data used to Estimate Discharges

Stream	Site ID	River Km	Discharge(m3/s)			Amount of data	Sample Date	Note
			Min	Average	Max			
Portneuf River	CMP-5	53.8		0.22		calculation*	July 29 -August 5, 2000	Chen (2001)
Portneuf River	At Inkom	51.5		1.22		1	July 29 -August 5, 2000	Chen (2001)
Portneuf River	CMP-8	33.3		1.77		1	7/20/1999	
Portneuf River	USGS Station 13075500	28.5	0.20	4.28	14.89	24	Sep.1966-Sep. 1998	
Portneuf River	Kraft Rd Bridge	25.9		5.16		1	7/20/1999	Excluded
Portneuf River	T-1	21.7		2.20		1	9/13/2000	
Portneuf River	Baliste Bridge	21.5	1.74	6.01	17.00	6	Jun. 1999-Jun.2000	
Portneuf River	T-2	21.3		3.01		1	9/13/2000	
Portneuf River	T-3	21.0		3.95		1	9/13/2000	
Portneuf River	T-4	20.5		5.13		1	9/13/2000	
Portneuf River	T-6	20.2		2.60		1	9/13/2000	Excluded
Portneuf River	T-7	19.8		4.67		1	9/13/2000	
Portneuf River	T-8	19.2		7.19		1	9/13/2000	
Portneuf River	T-9	18.8		7.82		1	9/13/2000	
Portneuf River	T-10	18.2		7.48		1	9/13/2000	
Portneuf River	Siphon Bridge	17.8	5.13	11.12	18.54	9	Sep.1971-Sep.2000	
Portneuf River	USGS Station 13075910	16.0	2.73	7.34	24.00	42	Aug.1971-Sep.1994	
Marsh Creek		53.3	0.02	0.96	9.31	65	Jun. 1980-Sep. 1998	
Rapid Creek		51.5		0.042		1	July 29 -August 5, 2000	Chen (2001)
Jackson Creek		51.5	0.003	0.11	0.14	3	June, 1986	
Indian Creek		50.7		0.017		1	July 29 -August 5, 2000	Chen (2001)
Mink Creek		40.0		0.15		1	July 29 -August 5, 2000	Chen (2001)
Gibson Jack Creek		37.6		0.07		1	July 29 -August 5, 2000	Chen (2001)
Johnny Creek		36.7		0.0014		1	July 29 -August 5, 2000	Chen (2001)
City Creek		30.9		0.018		1	July 29 -August 5, 2000	Chen (2001)
Pocatello Creek		26.8	0.01	0.31	2.72	12	July 1984-July 1986	
FMC Outfall		21.6	0.03	0.07	0.11	38	Jun. 1990-Sep.2000	
WPC Outfall		20.6	0.17	0.34	0.48	5	Jun. 1999-Sep.2000	
Baliste Spring		20.0	0.20	0.70	1.34	5	Jun.1970-1972, 2000	
Papoose Spring		18.3		0.86		-		No data for summer
Fort Hall Michaud Canal		17.6	2.70	3.78	4.87	5	1979-1981	

Note: *Flow of CMP-5 =1.22 (At Inkom)-0.96 (Marsh Creek)-0.042 (Rapid Creek)=0.22 m³/s

Table 11. Discharge Data for Headwaters, Point Sources, and Incremental Inflows

		Model	River	Flow (m ³ /s)
	Name	Reach No.	Distance (km)	
Headwater	Portneuf River	1	53.8	0.216
	Marsh Creek	2	53.3	0.965
	Rapid Creek	4	51.5	0.0418
	Indian Creek	7	50.7	0.0168
	Mink Creek	14	40.0	0.1467
	Gibson Jack Creek	17	37.6	0.072
	Johnny Creek	19	36.7	0.0014
	City Creek	25	30.9	0.0176
	Pocatello Creek	29	26.8	0.31
Point Source	Jackson Creek	4	51.5	0.11
	FMC Outfall	32	21.6	0.07
	WPC outfall	34	20.6	0.34
	Batiste Springs	35	20.0	-0.704
	Papoose Spring	37	18.3	0.86
	Fort Hall Michaud Canal	38	17.6	-3.78*
Incremental Inflow	Undocumented springs	30		0.138
	Undocumented springs	31		0.138
	Undocumented springs	32		0.138
	Undocumented springs	33		1.68
	Undocumented springs	34		0.84
	Undocumented springs	35		1.356
	Undocumented springs	36		0.63
	Undocumented springs	37		2.44

Note: * The negative means outflow from the system

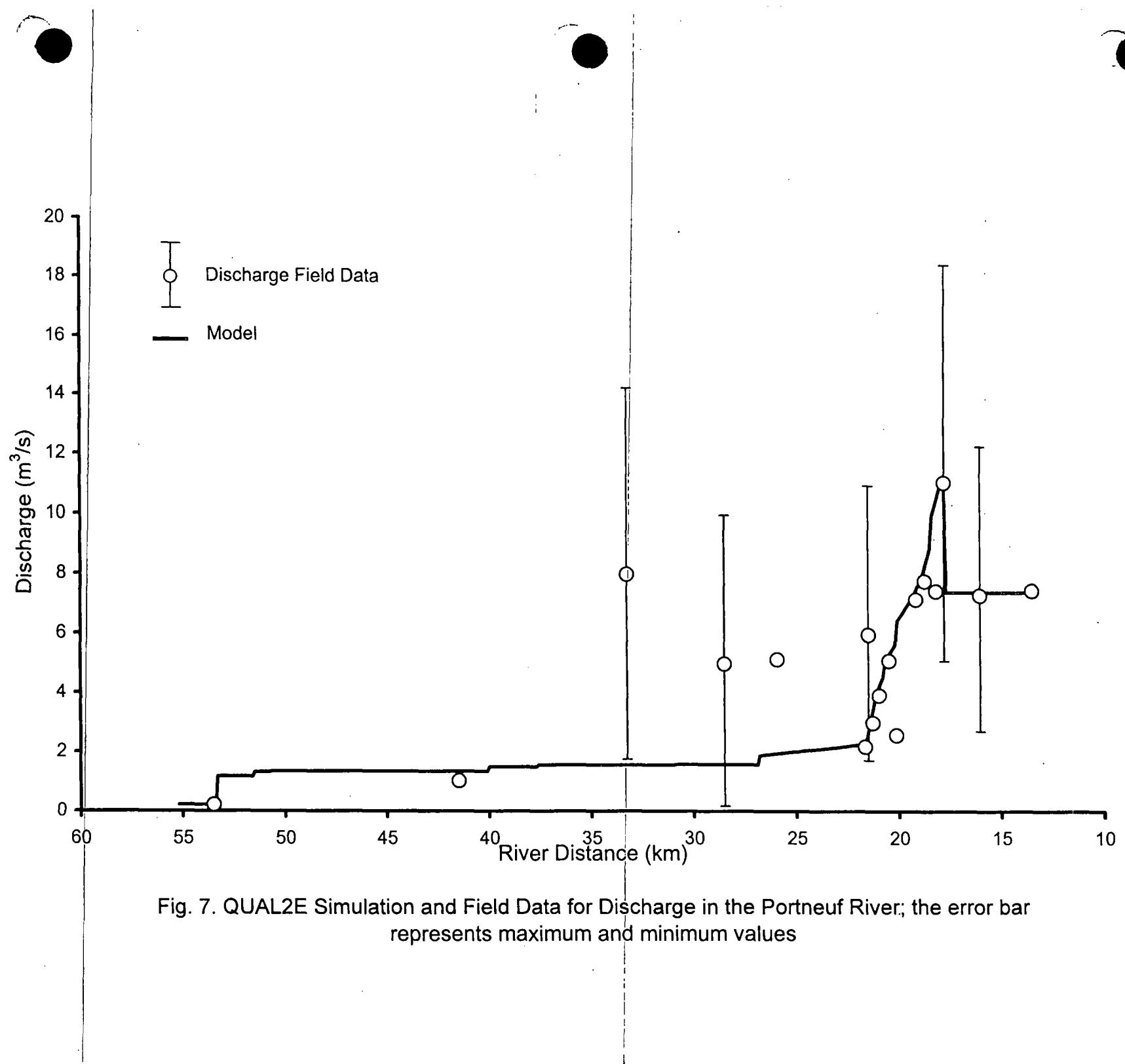


Fig. 7. QUAL2E Simulation and Field Data for Discharge in the Portneuf River; the error bar represents maximum and minimum values

Forcing Functions

Forcing functions mean the user specifies inputs in QUAL2E. There are four types of hydraulic and mass load forcing functions in addition to local climatological factors—headwater inputs, point sources or withdrawals, incremental inflow/outflow along a reach, and the (optional) downstream boundary concentrations (Brown and Barnwell, 1987). The downstream boundary concentrations were not defined due to lack of data. When the downstream boundary concentrations are not supplied, QUAL2E computes them by the zero gradient assumption. Because the concentration in the last cell is a computational artifact, it is removed from the concentration plots. The other three inputs are given in Tables 12 through 14.

The assumptions that were used for the forcing functions in the model are listed below:

1. When measured water temperature data was not available, 15°C was assumed for the purpose of calibrating the model. The average temperature of the FMC outfall (point source) is 79.67°C. Since the maximum input temperature that QUAL2E allows is 57.2°C, the temperature of the FMC Outfall was set to 57.2°C.
2. The average DO concentration of the "Portneuf Database" (Rackow, 2002b) is about 9.53 mg/L. When measured DO data was not available, DO concentration of 9.0 mg/L was assumed.

Table 12. Temperature, DO, BOD, Na, and Cl Data for Headwaters,
Point Sources, and Incremental Inflows

		River	TEMP (°C)	DO (mg/L)	BOD (mg/L)	Cl (mg/L)	Na (mg/L)
	Name	Reach No.	Distance (km)				
Headwater	Portneuf River	1	53.8	14.25	9.05	4.08	35.07
	Marsh Creek	2	53.3	17.54	9.1	4.36	50.07
	Rapid Creek	4	51.5	15	9	0.4**	15.8
	Indian Creek	7	50.7	15	9	0.4**	86.05
	Mink Creek	14	40.0	15	9.07	0.4	26.55
	Gibson Jack Creek	17	37.6	15	9	0.4**	10.65
	Johnny Creek	19	36.7	15	9	0.4**	98.35
	City Creek	25	30.9	15	9	2.48	12.8
	Pocatello Creek	29	26.8	11.33	9	0.4**	55.23
Point Source	Jackson Creek	4	51.5	15	9	0.4	15.8
	FMC Outfall	32	21.6	57.2	6.94	2.41	0
	WPC outfall	34	20.6	19.2	7.32	7.26	297
	Batiste Springs	35	20.0	15.46	8.96	3.44	64.44
	Papoose Spring	37	18.3	15	9	3.44	33.33
	Fort Hall Michaud Canal	38	17.6	14.6	9	4.36***	36.85***
Incremental Inflow *	Undocumented springs	30		15	7.56	0	40.3
	Undocumented springs	31		15	7.56	0	40.3
	Undocumented springs	32		15	7.56	0	40.3
	Undocumented springs	33		15	7.56	0	40.3
	Undocumented springs	34		15	7.56	0	26.8
	Undocumented springs	35		15	7.56	0	26.8
	Undocumented springs	36		15	7.56	0	26.8
	Undocumented springs	37		15	7.56	0	23.4

Note: * Assumed data based on Perry et al. (1990) and the effort of calibration

** Assumed data, equal to data of Mink Creek

*** Assumed data, equal to data of USGS 13075909 (17.8km)

Table 13. Nitrogen Cycle Data for Headwaters, Point Sources, and Incremental Inflows

		River	ORG N	NH3 N	NO2 N	NO3 N	
	Name	Reach No.	Distance (km)	(mg/L)	(mg/L)	(mg/L)	
Headwater	Portneuf River	1	53.8	0	0.09	0	1.16
	Marsh Creek	2	53.3	0.39	0.097	0	0.33
	Rapid Creek	4	51.5	0.342	0.021	0	0.98
	Indian Creek	7	50.7	0.312	0.027	0	1.6
	Mink Creek	14	40.0	0	0.9	0	0.082
	Gibson Jack Creek	17	37.6	0	0	0	0
	Johnny Creek	19	36.7	0	0	0	0.008
	City Creek	25	30.9	0	0	0	0.091
	Pocatello Creek	29	26.8	0.1	0.15	0	0.72
Point Source	Jackson Creek	4	51.5	0.372	0.038	0	1.48
	FMC Outfall	32	21.6	0	0.2	0	1.26
	WPC outfall	34	20.6	1	3.25	0	13.02
	Batiste Springs	35	20.0	0.48	1.09	0	5.58
	Papoose Spring	37	18.3	0.25	0.08	0	1.43
	Fort Hall Michaud Canal	38	17.6	0	0.1	0	1.92
Incremental Inflow *	Undocumented springs	30		0	0.05	0	2.54
	Undocumented springs	31		0	0.05	0	2.54
	Undocumented springs	32		0	0.05	0	2.54
	Undocumented springs	33		0	0.05	0	2.54
	Undocumented springs	34		0	0.22	0	2.54
	Undocumented springs	35		0.48	0.22	0	2.7
	Undocumented springs	36		0	0.05	0	2.8
	Undocumented springs	37		0	0.05	0	3

Note: The measured data for headwaters and point sources are in Appendix E. 0 means no data available

* Assumed data based on Perry et al. (1990) and the effort of calibration

Table 14. Phosphorus Cycle and Chlorophyll a Data for Headwaters, Point Sources, and Incremental Inflows

		River	ORG_P	DIS_P	TOT_P	Chl a
	Name	Reach No.	Distance (km)	(mg/L)	(mg/L)	(ug/L)
Headwater	Portneuf River	1	53.8	0.17	0.05	0.22
	Marsh Creek	2	53.3	0.09	0.03	0.12
	Rapid Creek	4	51.5	0.135	0.045	0.18
	Indian Creek	7	50.7	0.253	0.037	0.29
	Mink Creek	14	40.0	0.244	0.336	0.58
	Gibson Jack Creek	17	37.6	0.023	0.023	0.046
	Johnny Creek	19	36.7	0.023	0.023	0.046
	City Creek	25	30.9	0.015	0.014	0.029
	Pocatello Creek	29	26.8	0.09	0.07	0.16
Point Source	Jackson Creek	4	51.5	0.073	0.057	0.13
	FMC Outfall	32	21.6	0.102	0.184	0.286
	WPC outfall	34	20.6	1.04	0.44	1.48
	Batiste Springs	35	20.0	0.31	1.91	2.22
	Papoose Spring	37	18.3	0.04	0.03	0.07
	Fort Hall Michaud Canal	38	17.6	0.06	0.94	1
Incremental Inflow *	Undocumented springs	30		0.03	0.04	0.07
	Undocumented springs	31		0.03	0.04	0.07
	Undocumented springs	32		0.03	0.04	0.07
	Undocumented springs	33		0.25	4.6	4.85
	Undocumented springs	34		0.2	1.2	1.4
	Undocumented springs	35		0.03	0.1	0.13
	Undocumented springs	36		0.03	0.03	0.06
	Undocumented springs	37		0.03	0.03	0.06

Note: * Assumed data based on Perry et al. (1990) and the effort of calibration

DO concentration used for the incremental inflow was 75% of saturation DO as was used by Chaudhury et al. (1998) in their previous modeling effort. Because at 15°C, saturation DO (C_s) is 10.084 mg/L (Brown and Barnwell, 1987), DO of the incremental flow is 7.56 mg/L ($C = 10.084 * 75\% = 7.56 \text{ mg/L}$).

3. Headwater is located at 55.2 km, upstream from the mouth of the Portneuf River. Water quality was equal to the average observed data of at 53.8 km.
4. Although discharge from FMC is now discontinued, all the measured data were collected while the point source discharge was in practice. Because no monitored data available, NH₄-N concentration in FMC's discharge was assumed to be to 0.2 mg/L, which is the average monthly limit of the National Pollution Discharge Elimination System (NPDES) (EPA, 2001). The maximum daily Orthophosphate-P of 0.082 mg/L and total phosphorus of 0.184 mg/L permitted by NPDES were also used in the model because we thought the available phosphorus data were too old (1971-1974) and were inappropriate for the modeling.
5. NH₄-N in the WPC outfall is equal to the average monthly NH₄-N data (September, 3.25 mg/L) based on the WPC Plant's annual report (EPA, 2001) because the summer data (July-September) varied

- widely (0.65-7.6 mg/L).
6. BOD₅ in Papoose Spring is equal to that of Batiste Springs (3.44 mg/L). 0.08 mg/L NH4_N, 1.43 mg/L NO3_N, 0.03 mg/L DIS_P, 0.07 mg/L TOT_P, and 23.44 mg/L sodium concentration were chosen from Perry et al. (1990). ON_N concentration of 0.25 mg/L was determined by the model calibration.
 7. Incremental inflows are comprised of 27 known springs (Perry et al., 1990), undocumented springs, and groundwater. Some water quality data were from Perry et al. (1990), while others were determined by the model calibration.
 8. Water quality data for Jackson Creek were the same as Rapid Creek.
 9. For Fort Hall Michaud Canal (17.6 km), unknown data were the same as USGS 13075909 (17.8 km).
 10. TOT_P in Johnny Creek was equal to that of Gibson Jack Creek. DIS_P was equal to ORG_P for Johnny Creek, Gibson Jack Creek, and City Creek because only TOT_P data were available.

Calibration Results

Temperature. Simulated temperatures and measured data are shown in Figure 8. Simulated temperatures for the measured data sets are within the range of 1.0 to 2.0°C of the average measured values. Simulated temperature

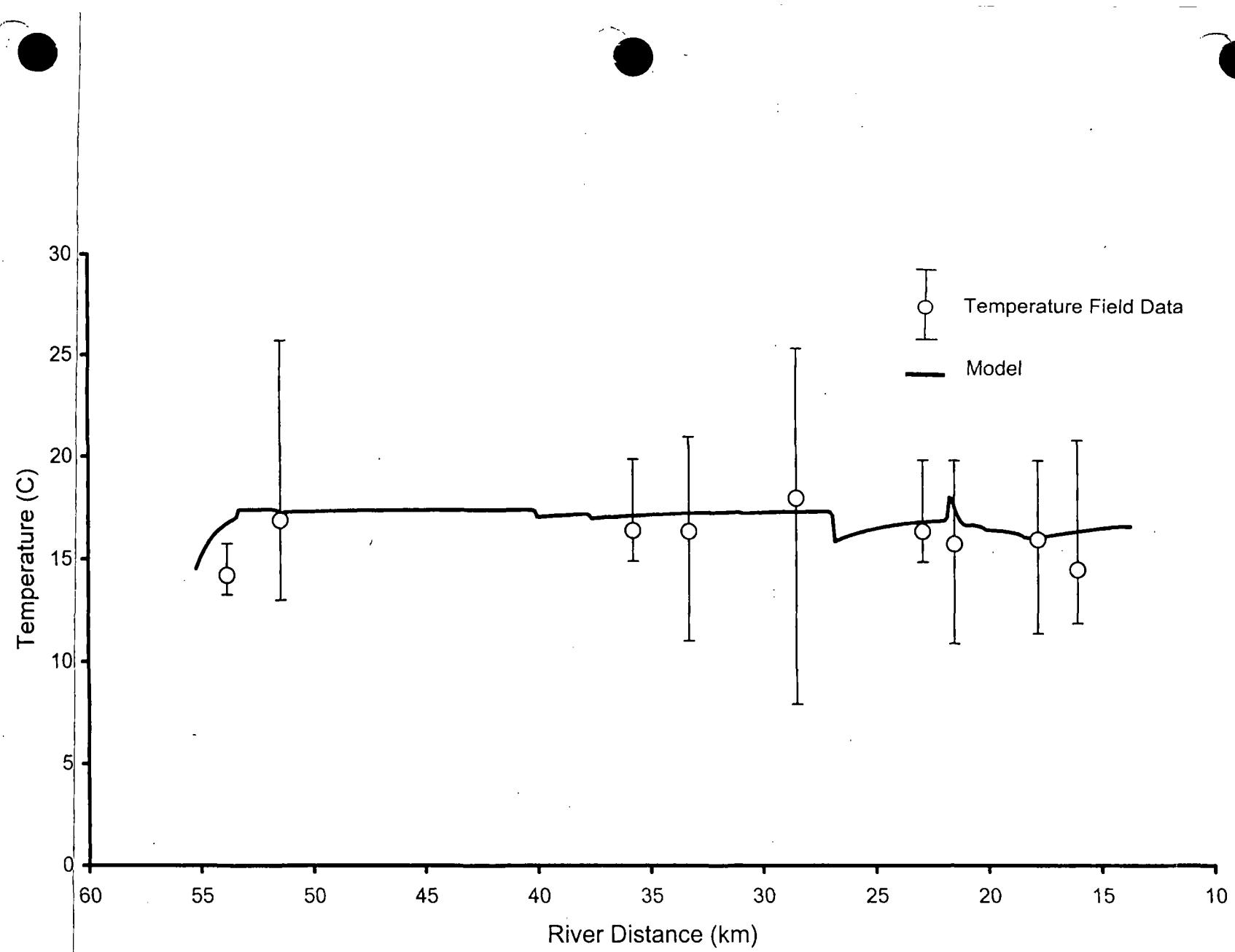


Fig. 8. QUAL2E Simulation and Field Data for Temperature in the Portneuf River; the error bar represents maximum and minimum values

has a peak at river distance of 21.6 km due to the high temperature discharge from FMC. The average temperature of the FMC outfall is 79.67 °C.

DO. Figure 9 is a plot of dissolved oxygen (DO) in the Portneuf River, which shows both the field and model results. It is important to note that model DO results are only applicable to day time (6:00 am – 20:00 pm) as the model is in a steady state mode (Brown and Barnwell, 1987). We assumed that the field DO measurements were performed during day time. DO in the river could be considerably lower during a night or overcast conditions during day because light necessary for photosynthesis is limited or not available. QUAL2E takes into account the cloudiness (Brown and Barnwell, 1987). The results show that daytime average DO varies slightly along the river reach studied, and consistently above 6 mg/L.

BOD₅. The model results and field data on BOD₅ are given in Figure 10. As is seen, BOD₅ concentration of the Portneuf River is very low. Noting that many of the available BOD₅ data were outdated (in 1970's), our model calibration effort was centered on relatively new data. As a result, a greater difference is shown between the old field data and the simulated results. The increases of BOD₅ at the junction of Marsh Creek (53.3km), the WPC outfall (20.6km), and Batiste Spring (20.0km) are likely due to the discharge from Marsh Creek (tributary) and the point sources, i. e., the WPC outfall and Batiste Springs.

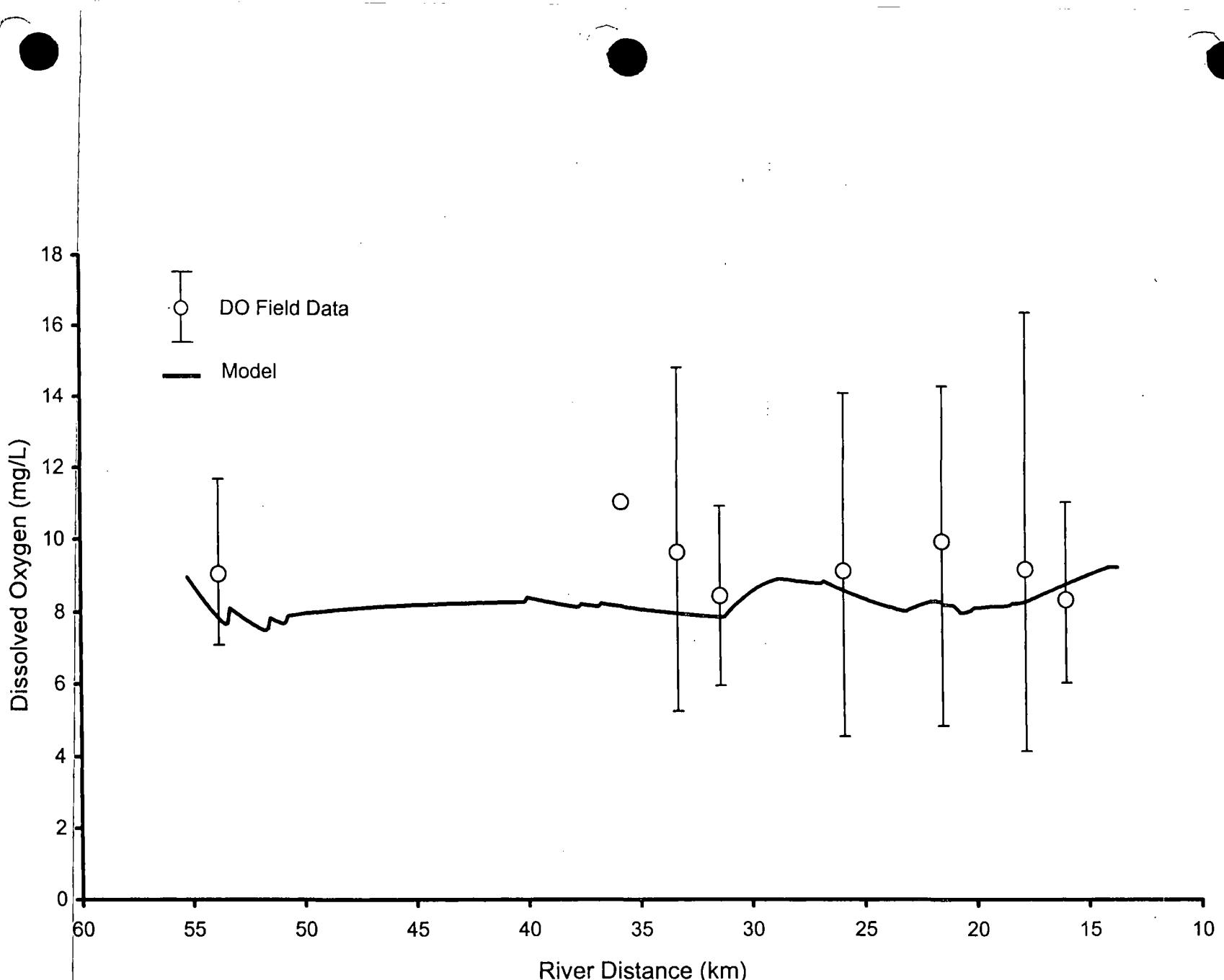


Fig. 9. QUAL2E Simulation and Field Data for Dissolved Oxygen in the Portneuf River; the error bar represents maximum and minimum values

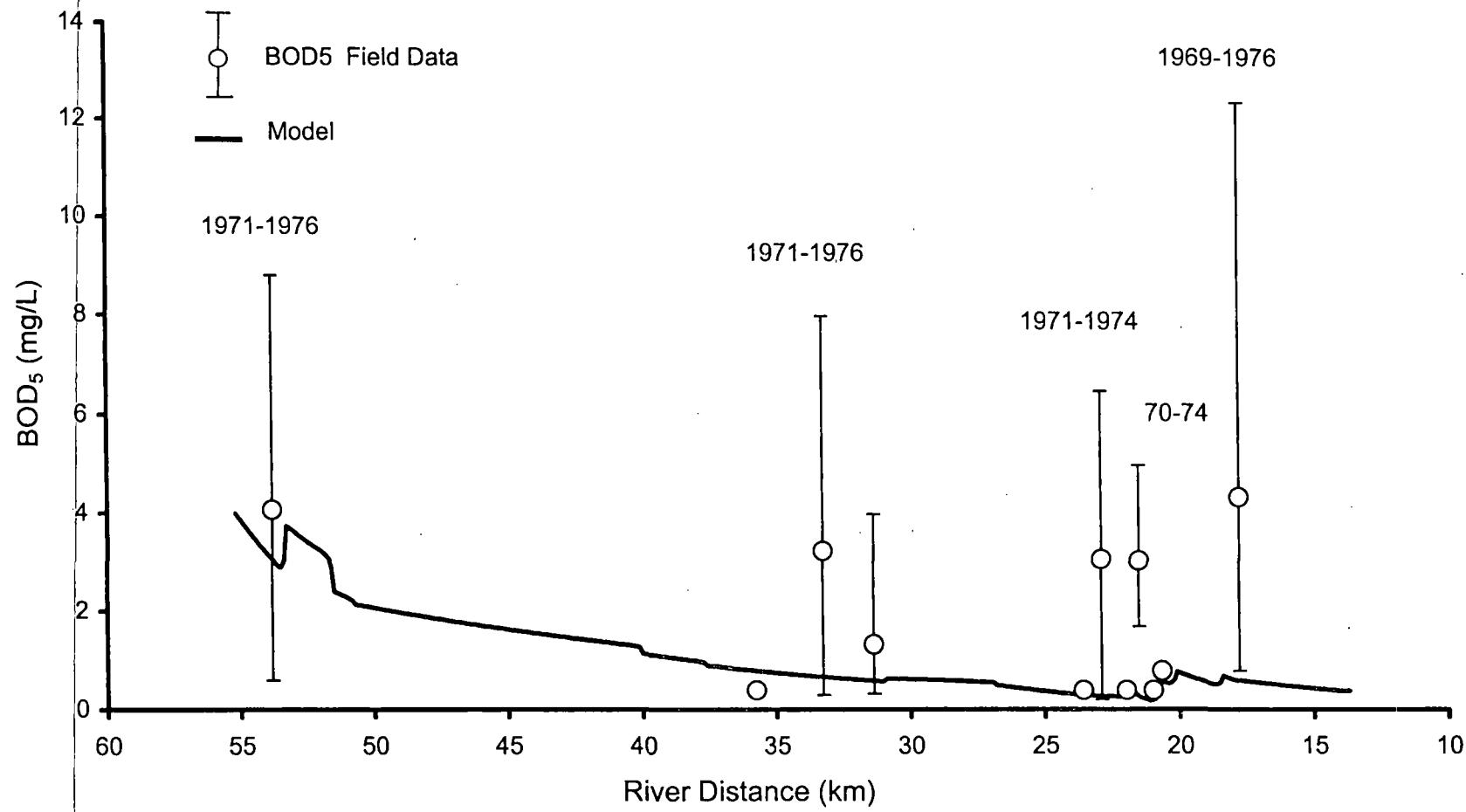


Fig. 10. QUAL2E Simulation and Field Data for 5-day Carbonaceous Biochemical Oxygen Demand in the Portneuf River; the error bar represents maximum and minimum values

Nitrogen. The Portneuf River model calibration for organic-N (ON_N), ammonia-N (NH4_N), nitrite-N (NO2_N), and nitrate-N (NO3_N) are shown, respectively, in Figures 11, 12, 13, and 14. The calibration effort was made using the relatively recent data. As is seen in these figures, the model results fit the recent field data reasonably well.

For the simulation of organic-N, 0 mg/L of ON_N was assumed for the model headwater (55.2 km). There is no ON_N concentration data available at 55.2 km. At the junction of the Portneuf River and Marsh Creek at 53.3 km, the ON_N concentration reached to 0.3 mg/L. The impact of Marsh Creek to the Portneuf River is unclear because of lack of field ON_N data. The simulated ON_N concentration decreases considerably in the Portneuf River reach from the Marsh Creek to Batiste Rd Bridge, although no recent data is available to verify the result in this region.

Between Batiste Rd Bridge (21.5 km) and Siphon Rd Bridge (17.8 km), there are two point sources; the WPC Plant outfall at 20.6 km and Batiste Springs at 20.0 km. It is likely there are numerous undocumented springs in this region. The organic-N level starts to increase near Batiste Rd Bridge, and peaked at the WPC outlet.

The simulated concentration of ammonia-N (NH4_N) is relatively low (0.1–0.3 mg/L N) in the Portneuf River reach from the headwater (55.2 km) to

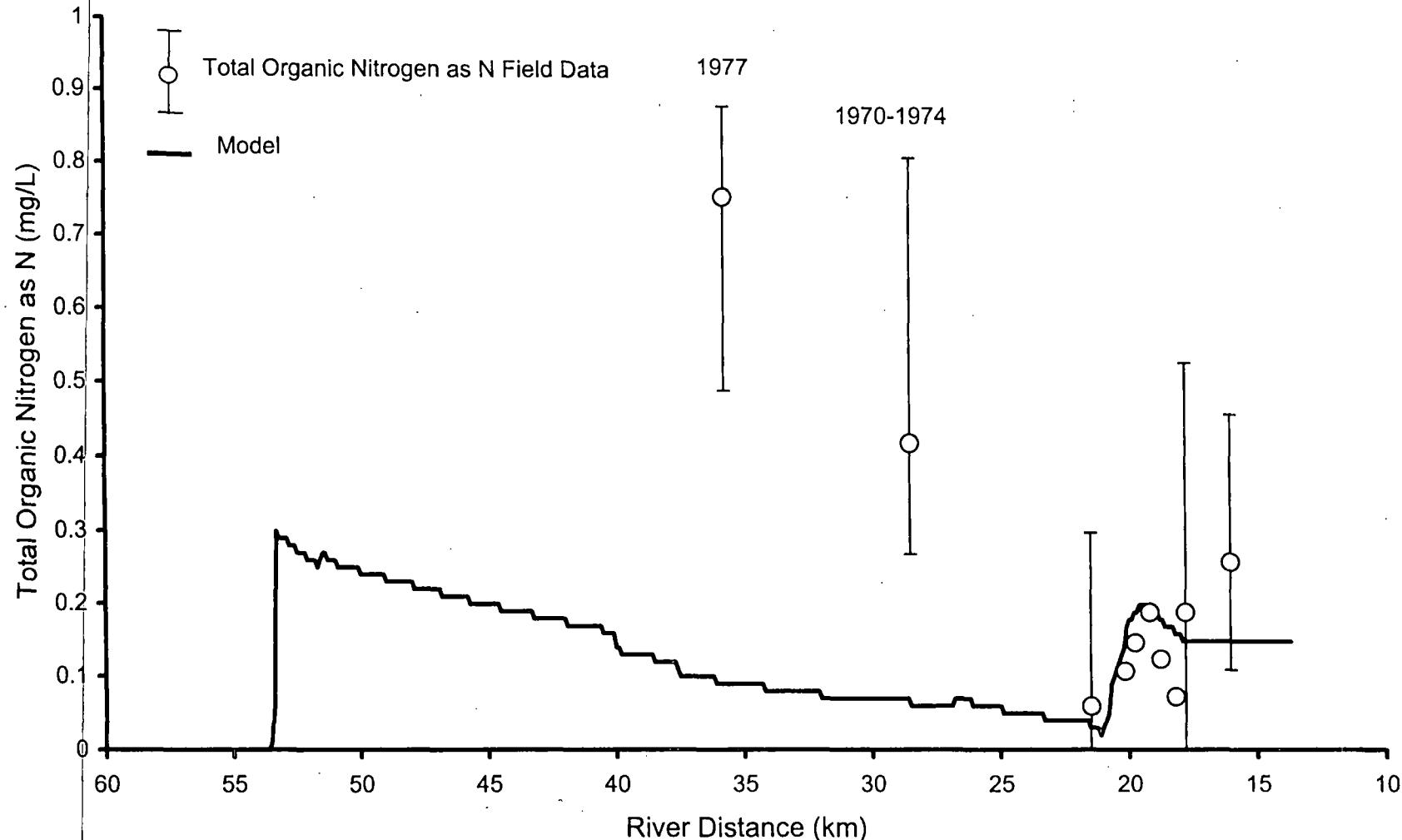


Fig. 11. QUAL2E Simulation and Field Data for Total Organic-N in the Portneuf River; the error bar represents maximum and minimum values

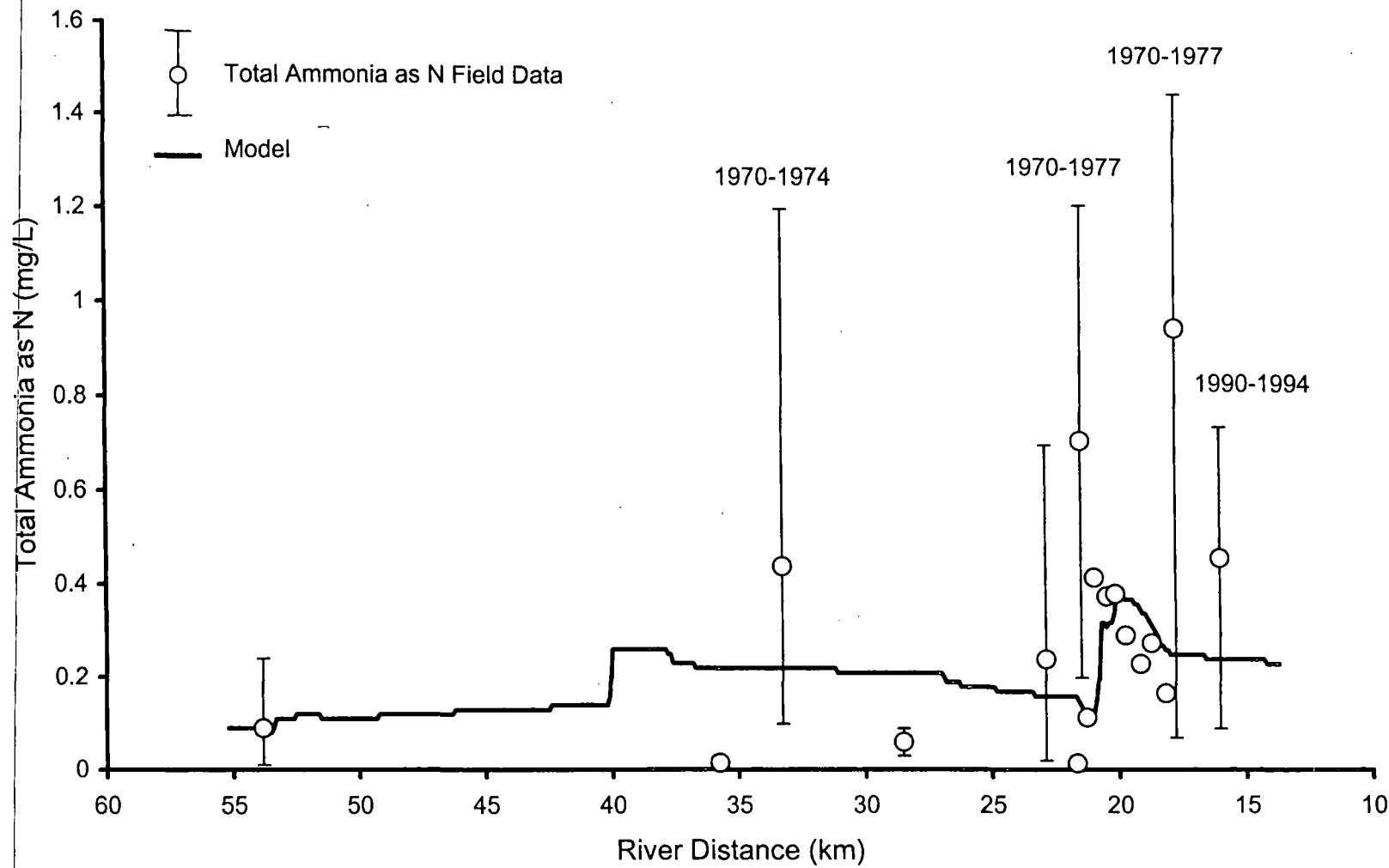


Fig. 12. QUAL2E Simulation and Field Data for Total Ammonia-N in the Portneuf River; the error bar represents maximum and minimum values

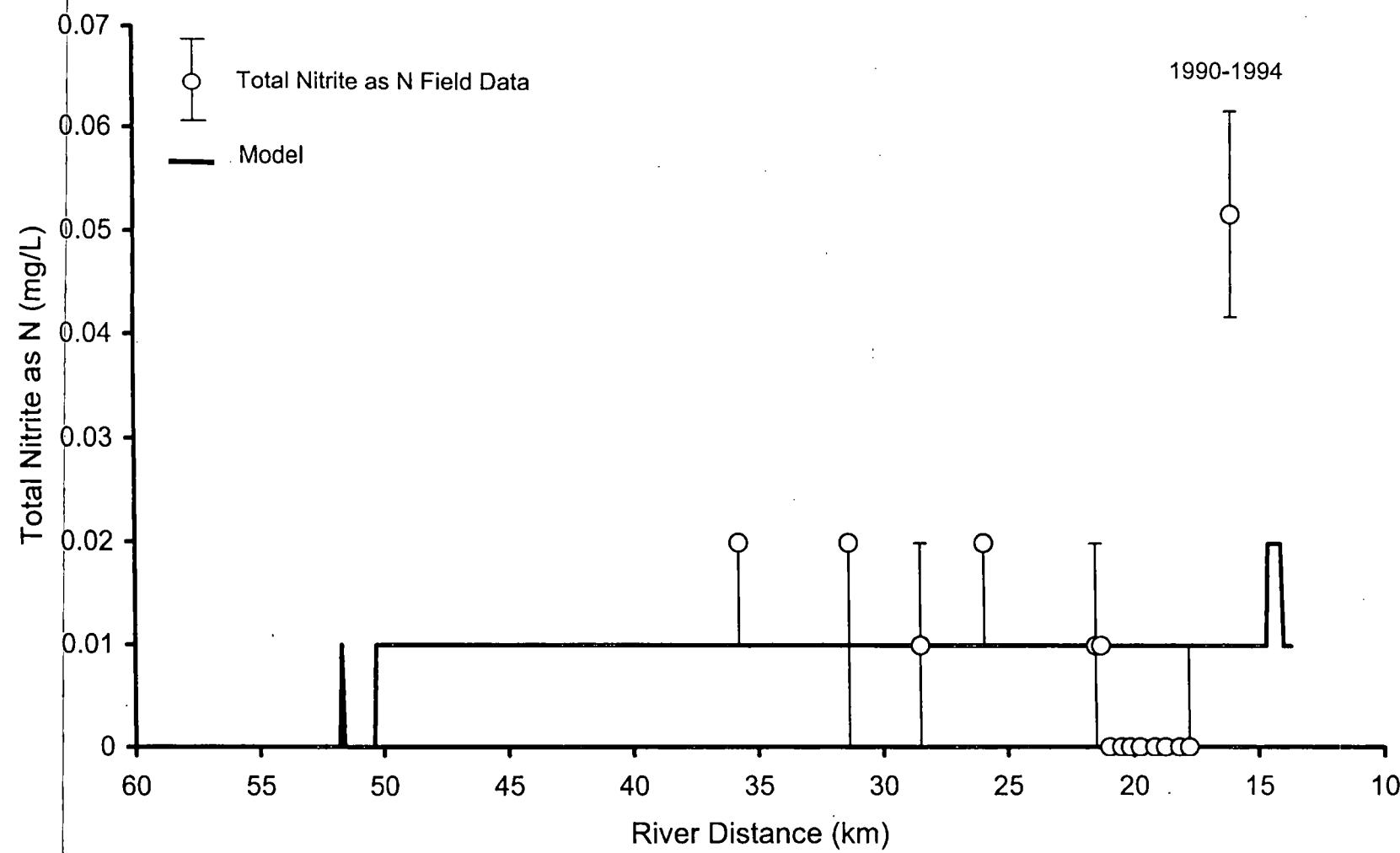


Fig. 13. QUAL2E Simulation and Field Data for Total Nitrite as N in the Portneuf River;
the error bar represents maximum and minimum values

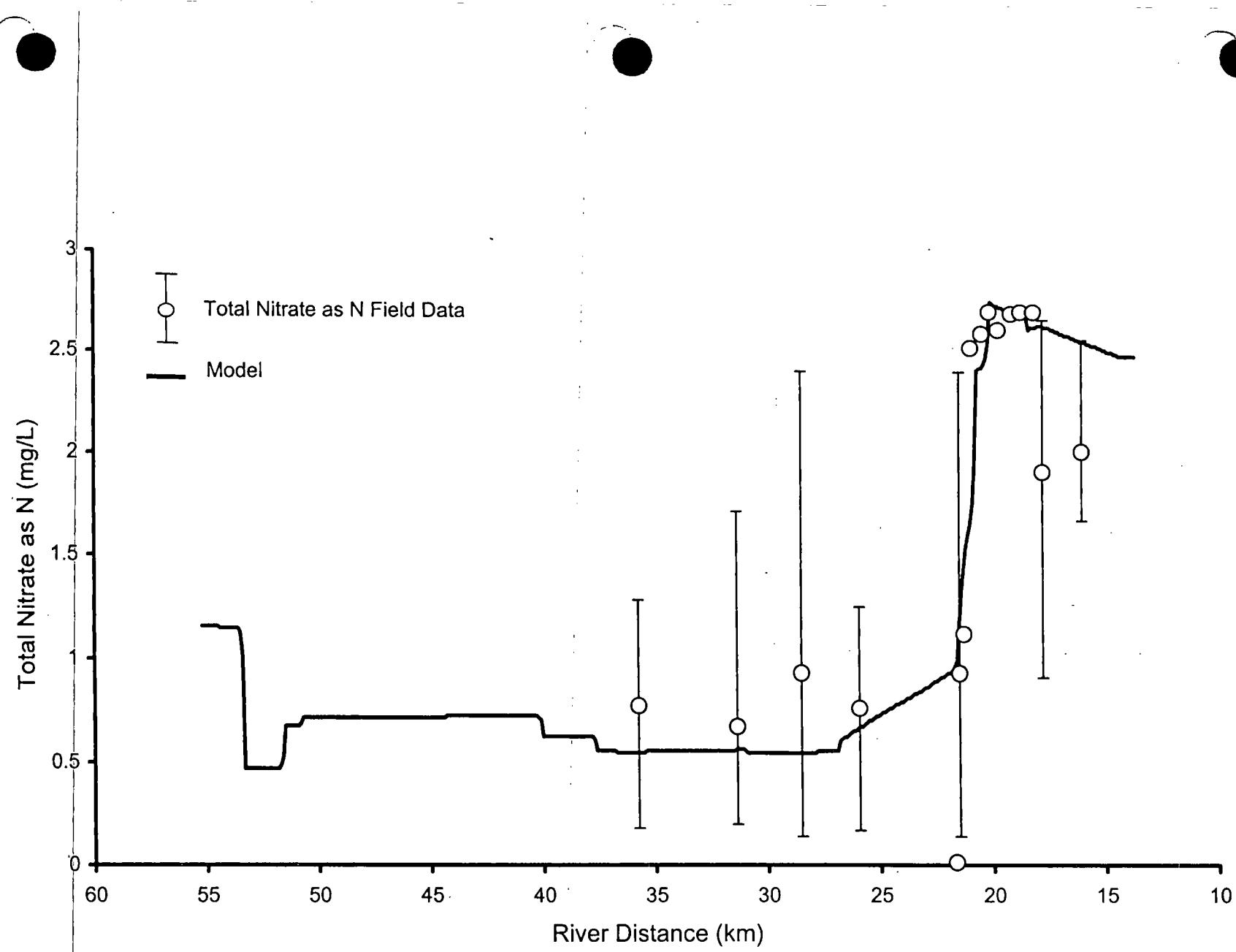


Fig. 14. QUAL2E Simulation and Field Data for Total Nitrate as N in the Portneuf River; the error bar represents maximum and minimum values

Batiste Rd Bridge (21.5 km). The model results indicate that the NH₄-N level increases at the junction of the Portneuf River and Mink Creek at 40.0 km. The cause of this increase in NH₄-N is unknown.

Similar to ON-N, NH₄-N concentration increases sharply at the WPC outfall (20.6 km) and Batiste Springs (20.0 km). The model results show that Batiste Springs, the WPC Plant outfall, and undocumented springs are the primary causes of the significant increase in ammonia-N concentration in the lower Portneuf River. The marked decreases in the low ON-N and NH₄-N are seen in the river reach between 20.6 and 20.0 km. It is probably due to undocumented springs or groundwater discharges containing relatively low levels of ON-N and NH₄-N.

It is noteworthy when comparing the recent filed data with the 70s' data (Figures 11 and 12), the levels of organic-N and ammonia-N decreased significantly in the Portneuf River and show the significant improvement of the water quality over the last 30 years.

The reported nitrite-N concentrations (0-0.02 mg/L) in the Portneuf River are very low, and insignificant in the nitrogen balance. The model simulation (Figure 13) also suggests that nitrite impact on water quality is insignificant.

Figure 14 shows a sharp decrease in nitrate-N (NO₃-N) at 53.3 km. This decrease is probably due to the larger flow (0.97 m³/s) and lower level of NO₃-N (0.33 mg/L) in Marsh Creek. The NO₃-N level rises slightly at Rapid Creek (51.5

km) and Indian Creek (50.7 km). Currently no data are available to verify the simulated results. The NO₃-N level sharply increases just above the WPC outfall and remains high through Batiste Springs.

In the most downstream element (13.5 km), simulated concentrations of nitrogen species decreased sharply. The reason for this sharp decrease is believed to be caused by the downstream boundary concentrations that were not supplied. The constituent concentrations in the most downstream element were computed by QUAL2E using the zero gradient assumption (Brown and Barnwell, 1987). Because of the possible artifact, the simulated concentration in the most downstream element (13.5 km) was manually removed from the plots.

Phosphorus. Model calibration results and available field data on dissolved-P (DIS_P), organic-P (ORG_P), and total-P (TOT_P) are shown in Figures 15, 16, and 17, respectively. As seen, the model simulated phosphorus species reasonably well in the Portneuf River. Similar to the nitrogen results, phosphorus levels increased dramatically in the river reach from Batiste Rd Bridge (21.5 km) to Siphon Rd Bridge (17.8 km). The increase in phosphorus concentrations is most likely due to the discharges from WPC, Batiste Springs, and other undocumented springs. In the river reach below Siphon Rd Bridge, the simulated phosphorus concentrations are higher than the field data observed at USGS 13075910 (16.0 km). This may be due to phosphorus uptake by aquatic vegetation (macrophytes) in the river. QUAL2E does not account for the

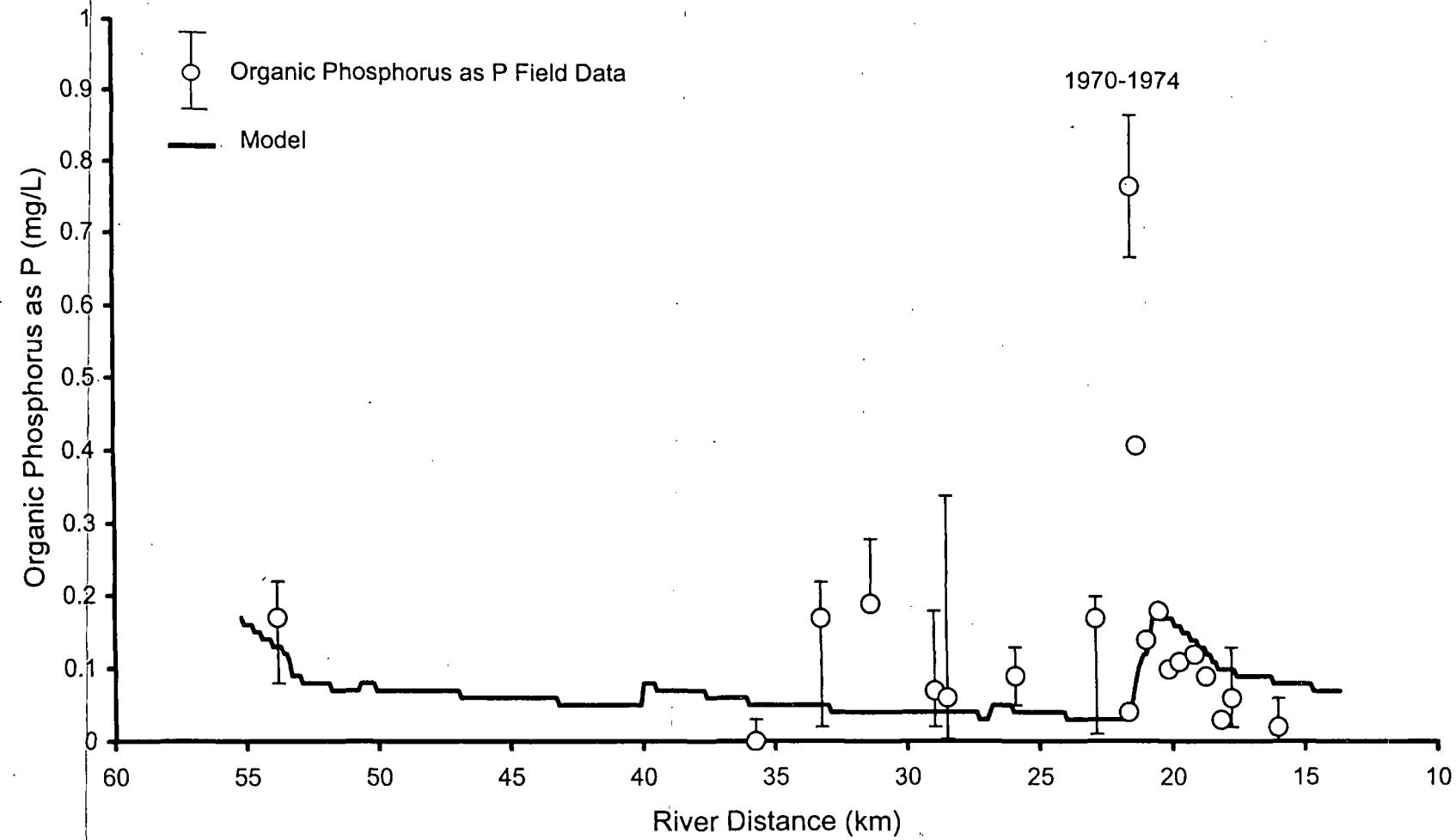


Fig. 15 QUAL2E Simulation and Field Data for Organic Phosphorus as P in the Portneuf River; the error bar represents maximum and minimum values

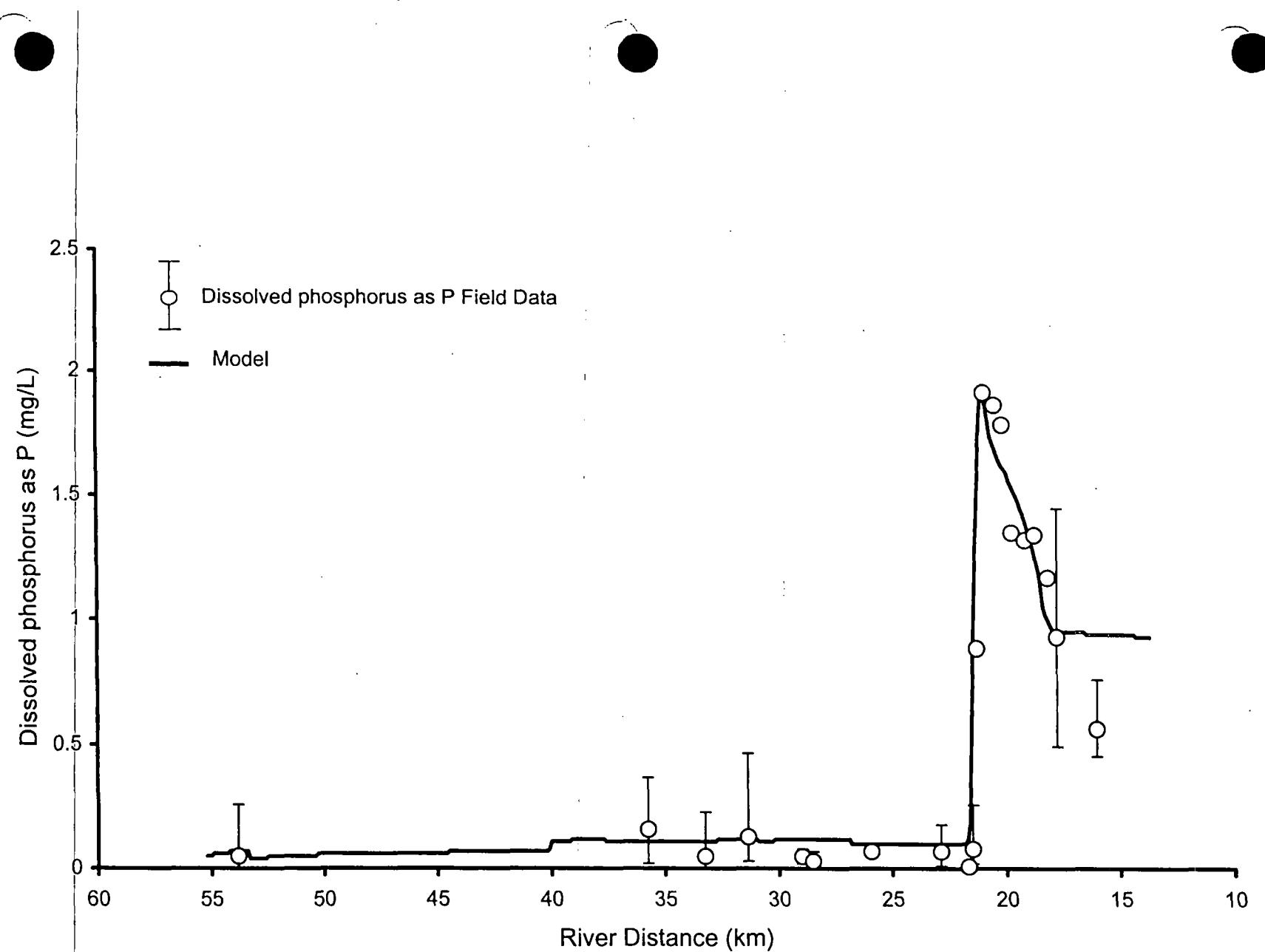


Fig. 16. QUAL2E Simulation and Field Data for Dissolved Phosphorus as P in the Portneut River; the error bar represents maximum and minimum values

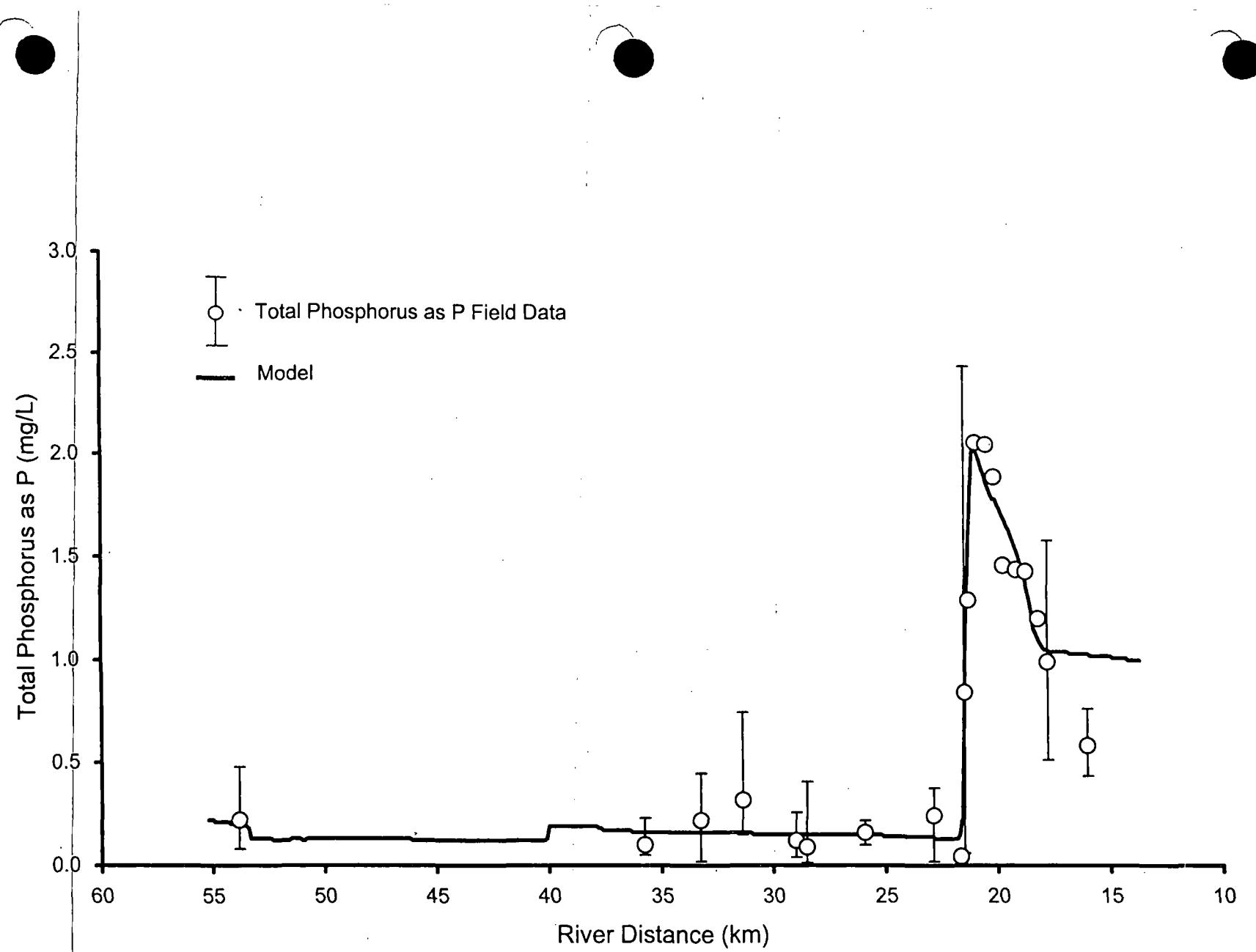


Fig. 17. QUAL2E Simulation and Field Data for Total Phosphorus as P in the Portneuf River;
the error bar represents maximum and minimum values

phosphorus assimilation by macrophytes. It has been reported that the phosphorus concentrations in springs in the reach (13.5 - 17.8 km) are lower than those in Batiste Springs (Perry et al., 1990).

The simulated TOT_P is the sum of DIS_P and ORG_P (Brown and Barnwell, 1987). The concentration profile of ORG_P (Figure 15) is similar to those of DIS_P and TOT_P. The concentration in the river above Batiste Rd Bridge (21.5 km) is quite low and static. The highest ORG_P concentration occurred in the river slightly above the WPC outfall (20.6 km).

The primary form of phosphorus in the Portneuf River is DIS_P. The concentrations of DIS_P and TOT_P from 21.7 km to 21.0 km, Reach 33 (Table 14) were assumed to be 4.6 and 4.85 mg/L, respectively. Note that, however, the reported average phosphorus concentrations in the discharge water from WPC during summer period were considerably lower (0.44 mg/L for DIS_P and 1.48 mg/L for TOT_P). In a recent study (EPA 2001), the maximum DIS_P and TOT_P concentrations in the discharge from WPC were 7.5 and 8.3 mg/L, respectively (April 30, 2000).

As was seen in the simulation of nitrogen, in the most downstream element (13.5 km), simulated concentration of TOT_P, DIS_P, and ORG_P decreased sharply. Because of the potential artifact described previously, the concentrations in the most downstream element were discarded manually.

Algae as chlorophyll a. There is no chlorophyll a (chl a) data in the

"Portneuf Database" (Rackow, 2002b). For the purpose of this modeling, The concentration of chl a was estimated in Chapter III using equations (33) to (35). The model calibration results are shown in Figure 18. As seen, in the river reach from headwater (55.2 km) to Batiste Rd Bridge (21.5 km), the concentration of chl a remains low and static. Significant growth of algae is indicated by the elevated chl a concentration in the river from Batiste Rd Bridge (21.5 km) to the WPC outfall (20.6 km). The rapid increase in chl a is expected to be due to the high levels of nutrients (nitrogen, phosphorus) in the discharges from the WPC outfall, Swanson Springs, and undocumented springs. The chl a level drops sharply near and below Batiste Springs (20.0 km). Campbell et al. (1992) and Chen (2001) reported the eutrophication of the lower Portneuf River.

Conservative Elements. Chloride (Cl) and sodium (Na) were selected as conservative elements for the QUAL2E simulation of the Portneuf River. Model results for Cl and Na are shown in Figures 19 and 20, respectively. The simulation results in Figure 19 indicate that the WPC outfall and Batiste Springs are the major sources of Cl to the river. The marked changes in Cl concentrations are predicted at the junctions of the river and tributaries including Marsh Creek (53.3 km), Rapid Creek (51.5 km), Indian Creek (50.7 km), Mink Creek (40.0 km), Gibson Jack Creek (37.6 km), Johnny Creek (36.7 km), City Creek (30.9 km), and Pocatello Creek (26.8 km). These changes are due to the concentration difference between the river and the tributaries. Similar results were obtained for Na (Figure 20).

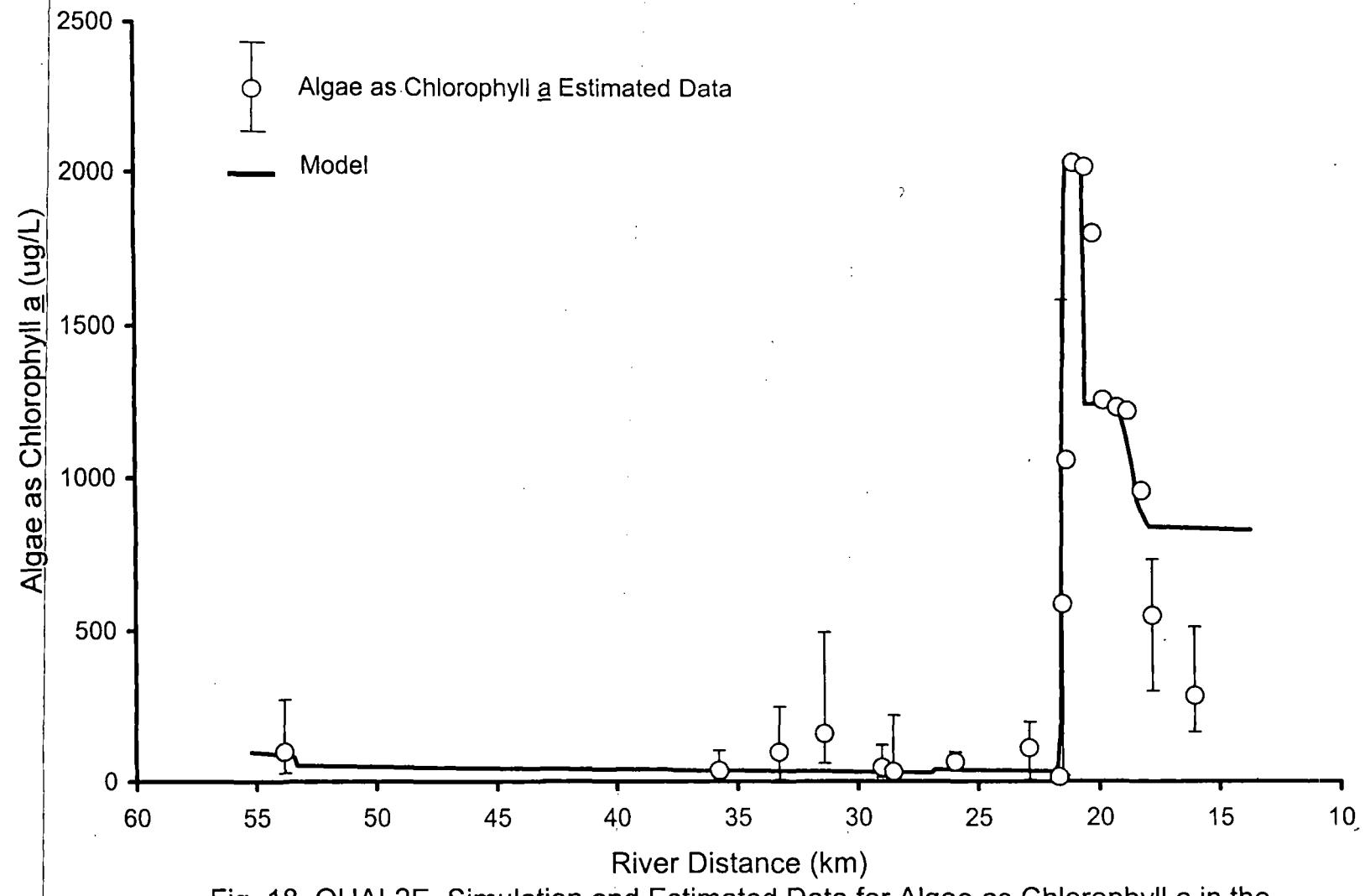


Fig. 18. QUAL2E Simulation and Estimated Data for Algae as Chlorophyll a in the Portneuf River; the error bar represents maximum and minimum values

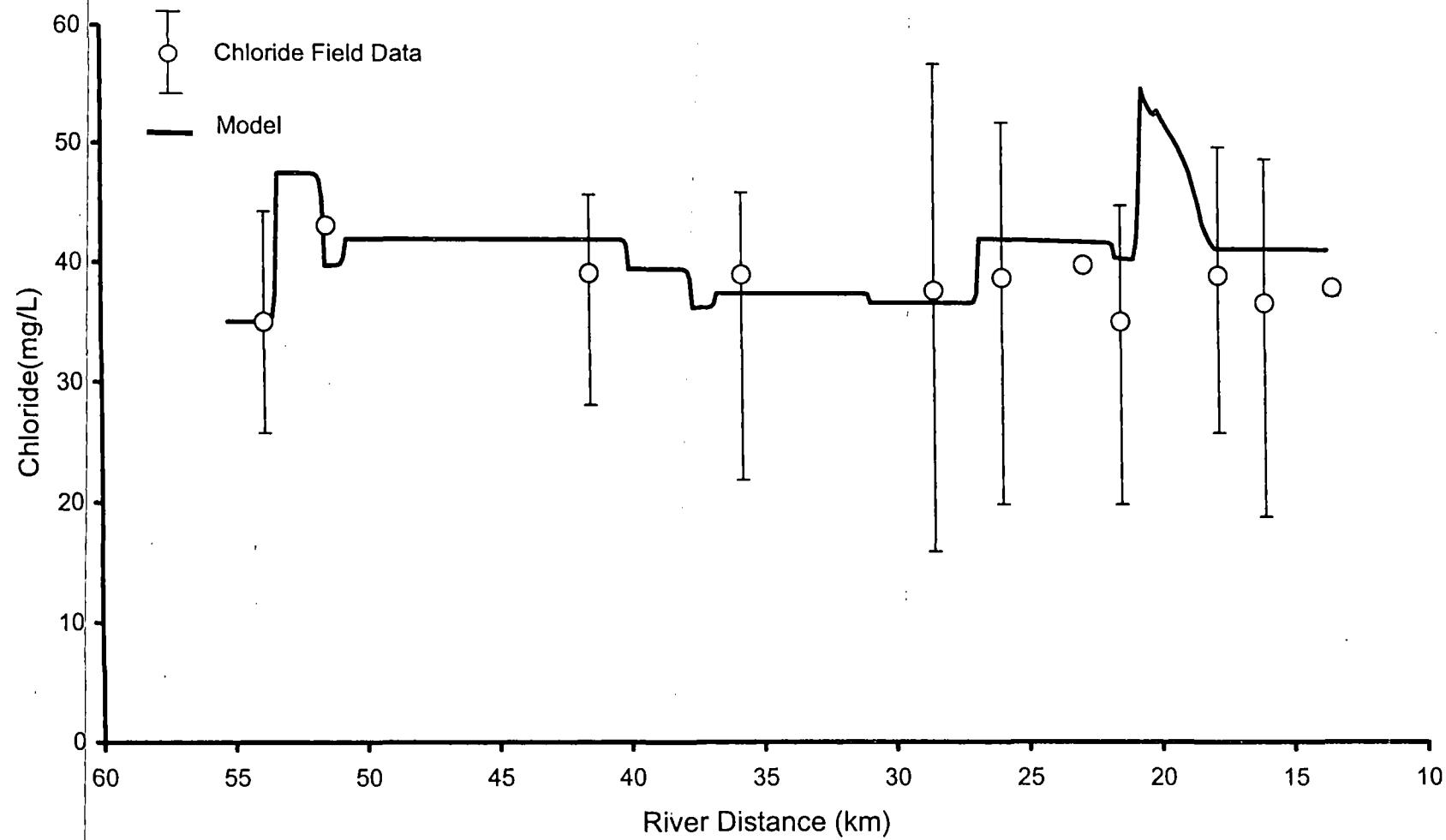


Fig. 19. QUAL2E Simulation and Field Data for Chloride in the Portneuf River; the error bar represents maximum and minimum values

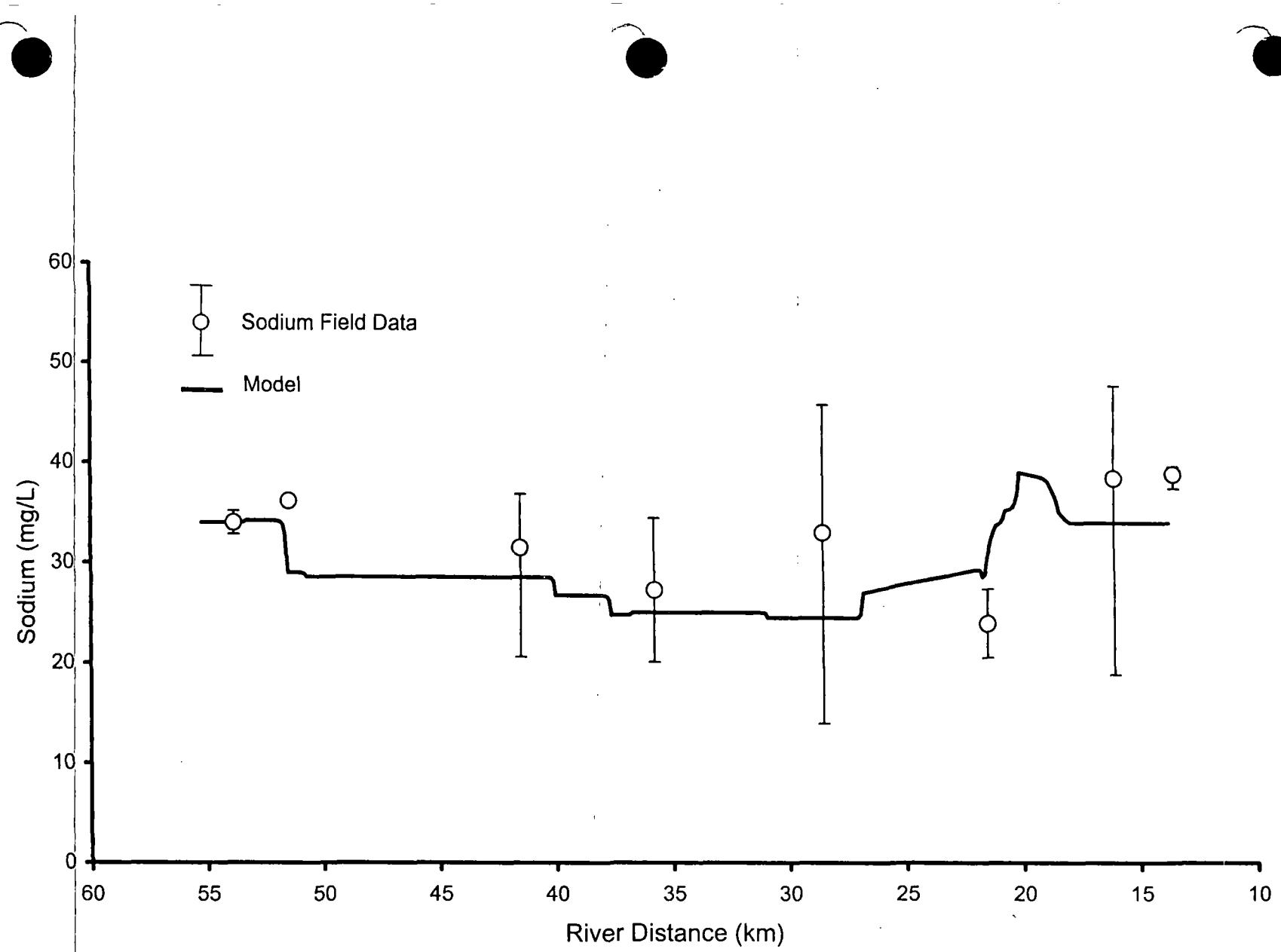


Fig. 20. QUAL2E Simulation and Field Data for Sodium in the Portneuf River; the error bar represents maximum and minimum values

CHAPTER V

UNCERTAINTY ANALYSIS

Monte Carlo Simulation

QUAL2E provides three uncertainty analysis techniques, sensitivity analysis, first order error analysis, and Monte Carlo simulation. Monte Carlo simulation was selected for the model.

"Monte Carlo simulation is a method for numerically operating a complex system that has random components (Brown and Barnwell, 1987)." The advantages of Monte Carlo techniques include its linear computational complexity and the accuracy of output distribution that can be estimated by using standard statistical techniques. It is preferred for large models with many uncertain inputs (Morgan et al., 1990). It has been used in water quality modeling (Freedman et al., 1988), and environmental risk management such as human exposure assessments (Smith, 1994).

The knowledge of uncertain characteristics of the model inputs is one of the fundamental requirements for performing uncertainty analyses (Brown and Barnwell, 1987). QUAL2E has 139 variable inputs; 97 of them were used in the model. They were divided into global (35), hydraulic/climatology (13), reaction coefficient (14), incremental inflows (11), headwater (12), and point loads (12)

(Appendix G). To determine the variance of these variables is a time-consuming work, one that requires considerable amounts of actual data. QUAL2E provides a set of default values for all inputs. Due to lack of actual data to be analyzed, we used the default values provided in the QUAL2E document (Brown and Barnwell, 1987).

Lognormal probability distribution is the most widely used environmental distribution expression (Mackay and Paterson, 1984). The advantages of it are that it always yields positive concentrations and gives distributions corresponding to polluted environments (Mackay and Paterson, 1984). Therefore, it was selected for all the variables except temperature. Normal distribution was selected for temperature variables. A summary of input variance conditions are shown in Appendix G.

The QUAL2E manual (Brown and Barnwell, 1987) recommended at least 2000 simulations to achieve estimates of output standard deviations with 95% confidence intervals of 5%. In this study, 5000 simulations were performed.

Summary statistics and frequency distributions at user-defined locations are provided by the Monte Carlo simulation computation in QUAL2E (Brown and Barnwell, 1987). The summary output includes: base mean, simulated mean, bias, minimum, maximum, range, standard deviation, coefficient of variation, skew coefficient, frequency and cumulative frequency distributions. The maximum number of locations (computational elements) that QUAL2E allows in

one run is five. The following locations were selected: upstream (Reach 3 Element 10, 52.3 km), mid-reach (Reach 21 Element 10, 34.5 km), downstream (Reach 37 Element 5, 18.3 km), and two locations that we are most concerned about, Reach 34 Element 4 – junction of the Portneuf River and the WPC outfall, 20.6 km, and Reach 35 Element 5 – junction of the Portneuf River and Batiste Springs, 20.0 km.

Uncertainty Analysis

Among the 33 summary outputs, DO, NH₄_N, NO₃_N, TOT_P, and algae are of most our concern (Appendix G). The frequency distributions for DO, NH₄_N, NO₃_N, TOT_P, and algae are shown in Figures 21-30, respectively. The algae data at 20.6 km (Reach 34 Element 4) and 20.0 km (Reach 35 Element 5) showed marked negative skewness, the others exhibited little skew.

Dissolved Oxygen (DO). According to IDAPA58.01.02.250.02 (IDAPA, 2001), "for cold water aquatic life/seasonal cold water aquatic life, Dissolved Oxygen concentrations exceeding six (6) mg/L at all times". At all the 5 locations, the number of Monte Carlo realizations of the concentration of DO that occurred below 6.0 mg/L was 0% (see Figure 22). The average concentrations of DO excluding night time, should exceed 6.0 mg/L, 100% of the time.

Ammonia Nitrogen (NH₄ N). Ammonia is toxic to aquatic organisms. The toxicity depends on pH and temperature (IDAPA58.01.02, 2001). In aqueous

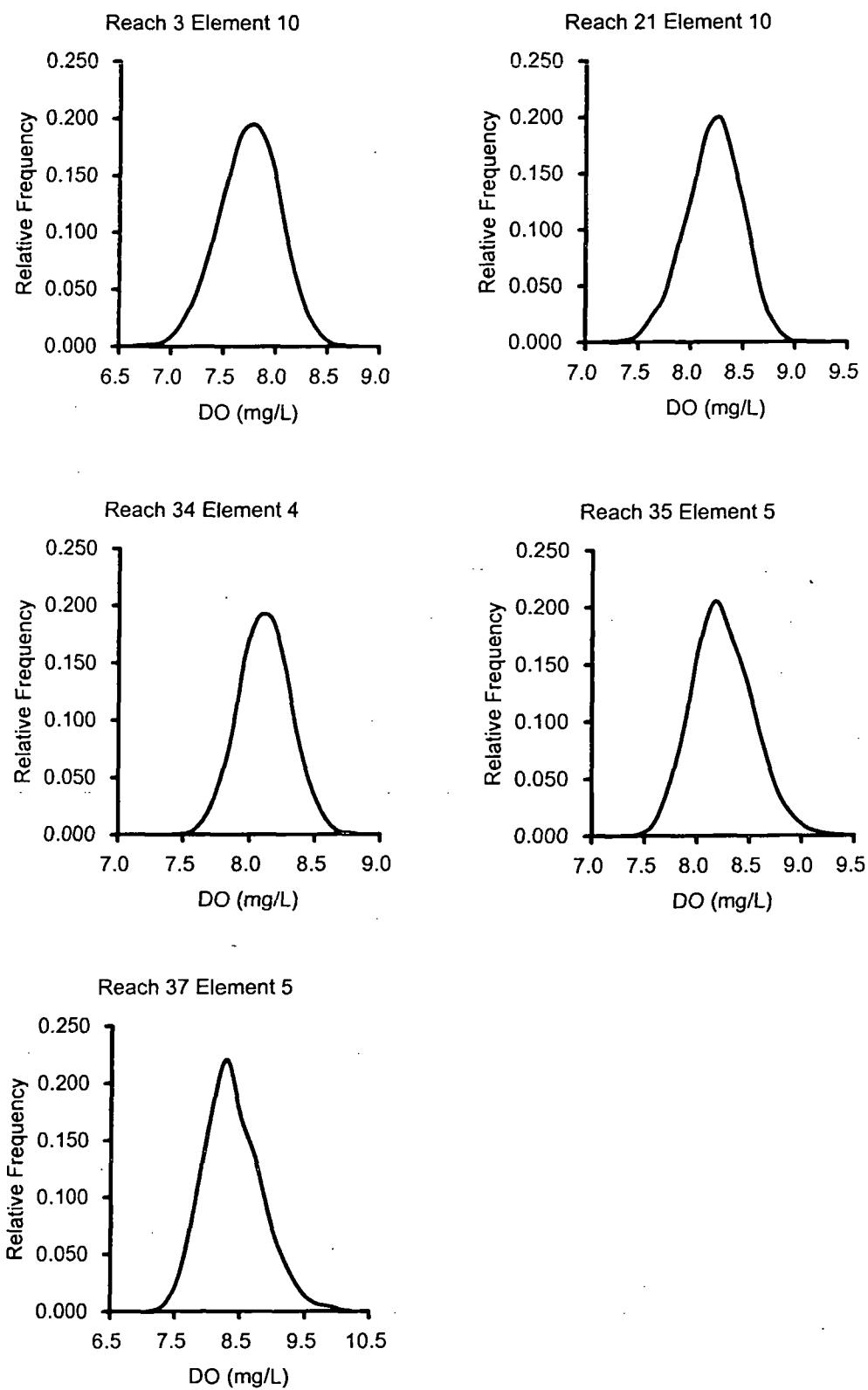


Fig. 21. Frequency Distribution for Dissolved Oxygen

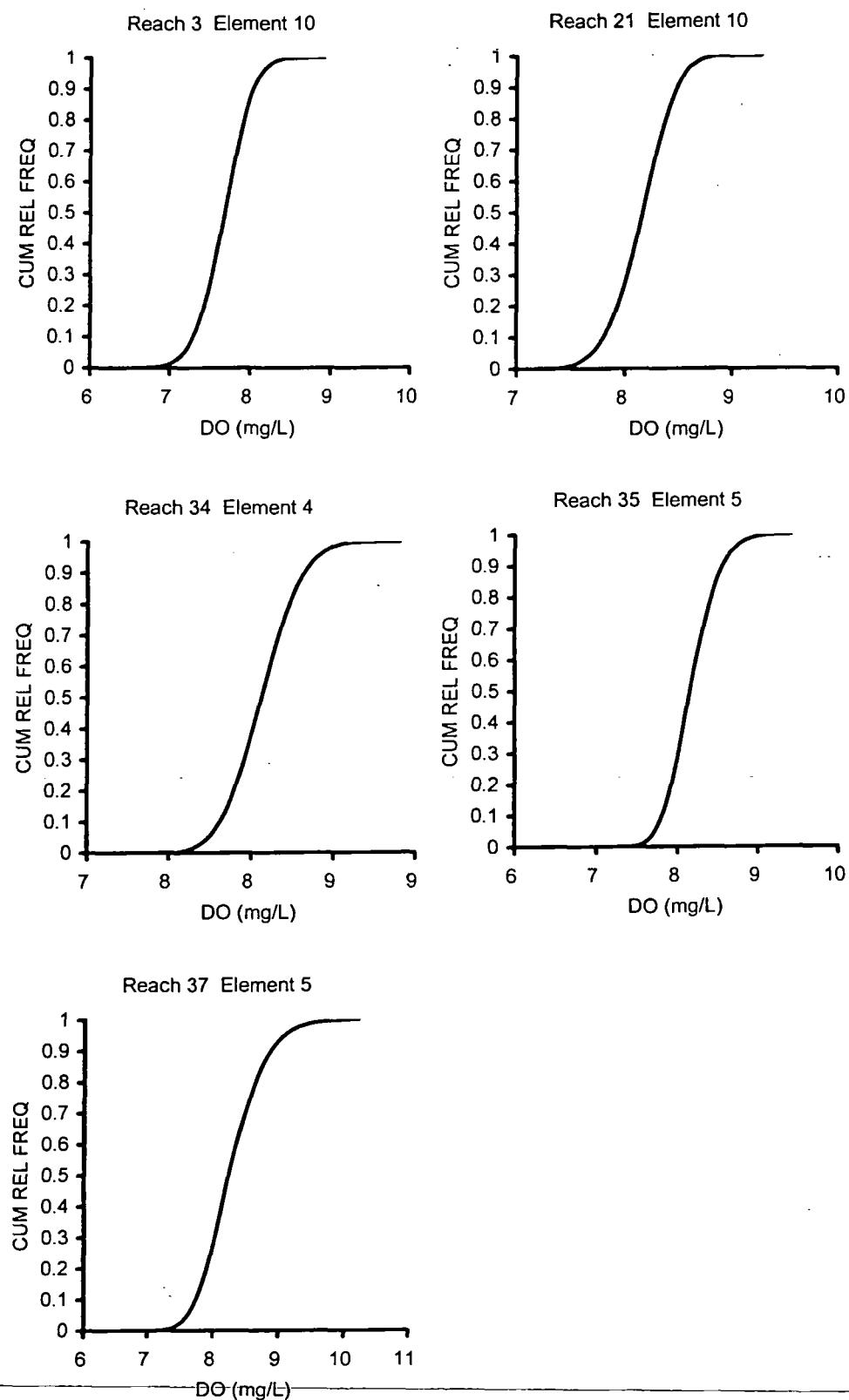


Fig. 22. Cumulative Distribution Function for Dissolved Oxygen

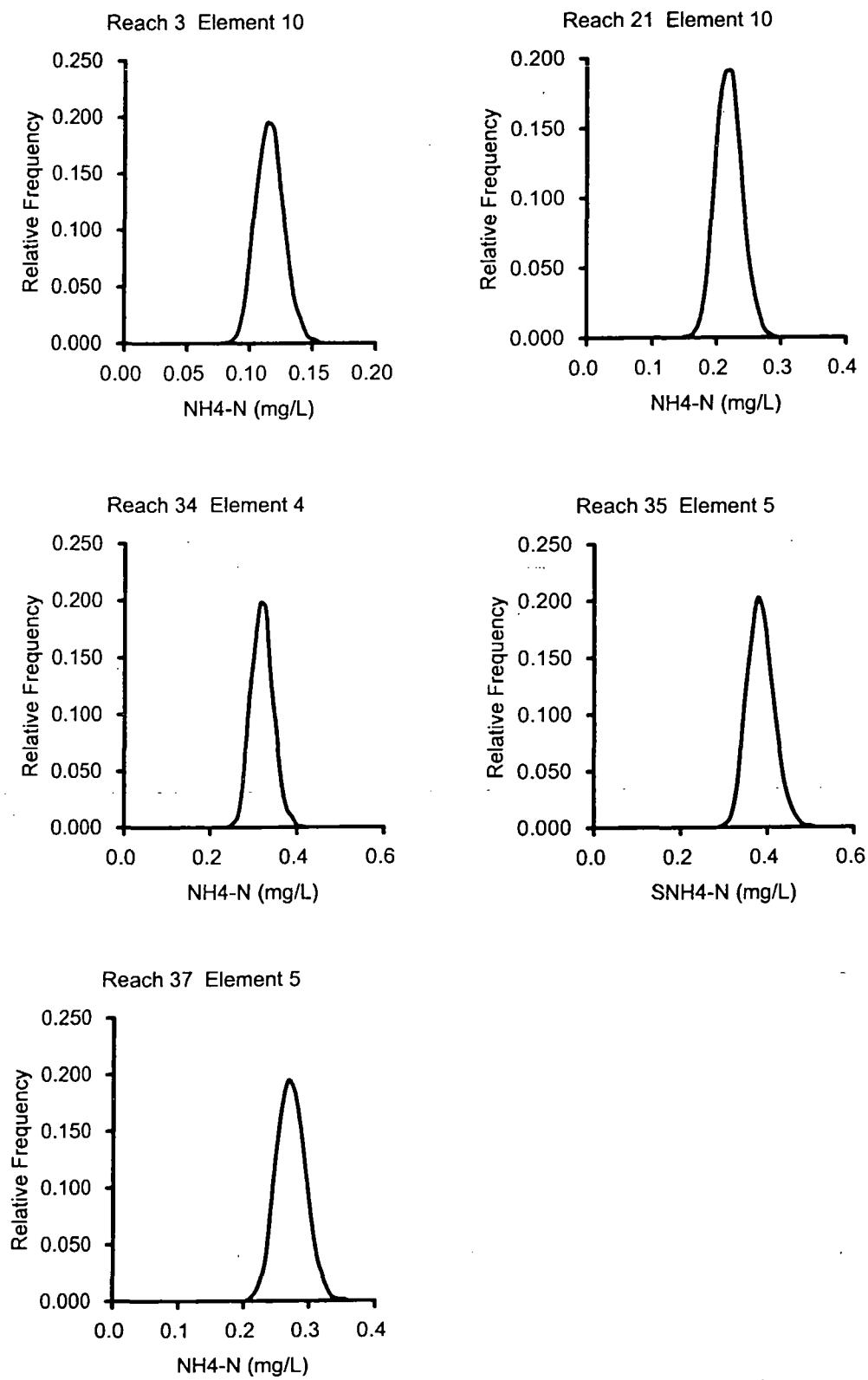


Fig. 23. Frequency Distribution for Ammonia Nitrogen as N

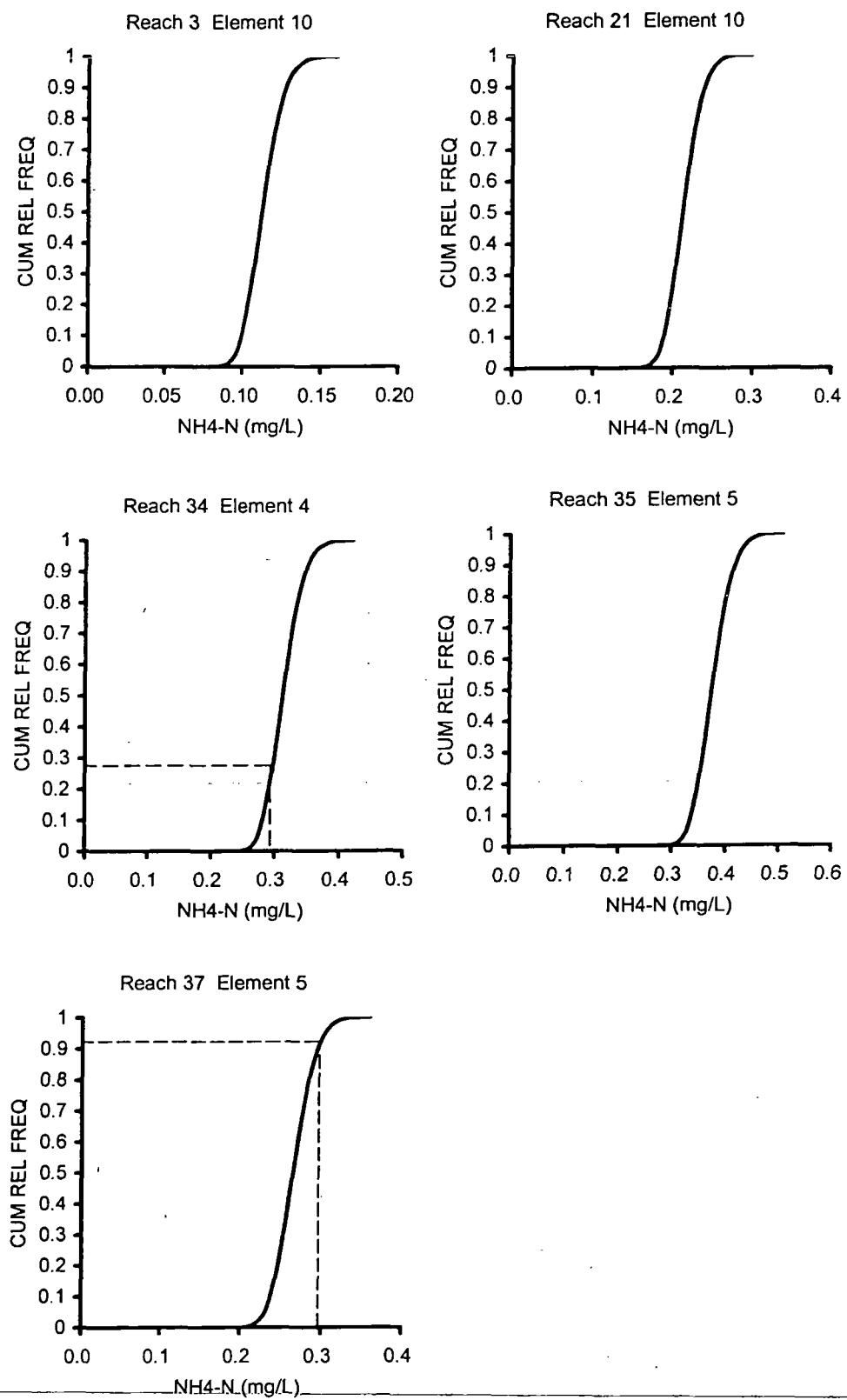


Fig. 24. Cumulative Distribution Function for Ammonia Nitrogen as N

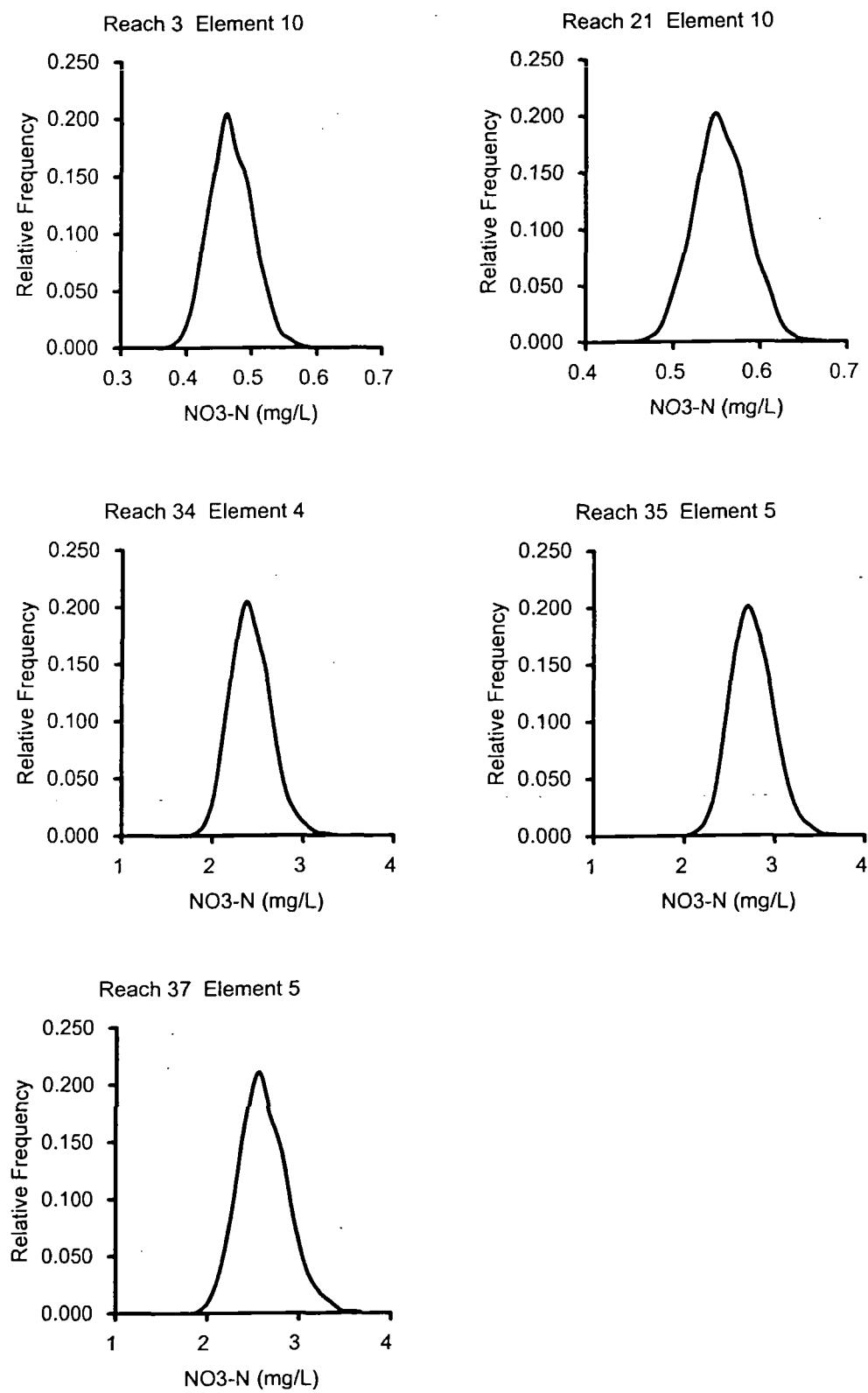


Fig. 25. Frequency Distribution for Nitrate Nitrogen as N

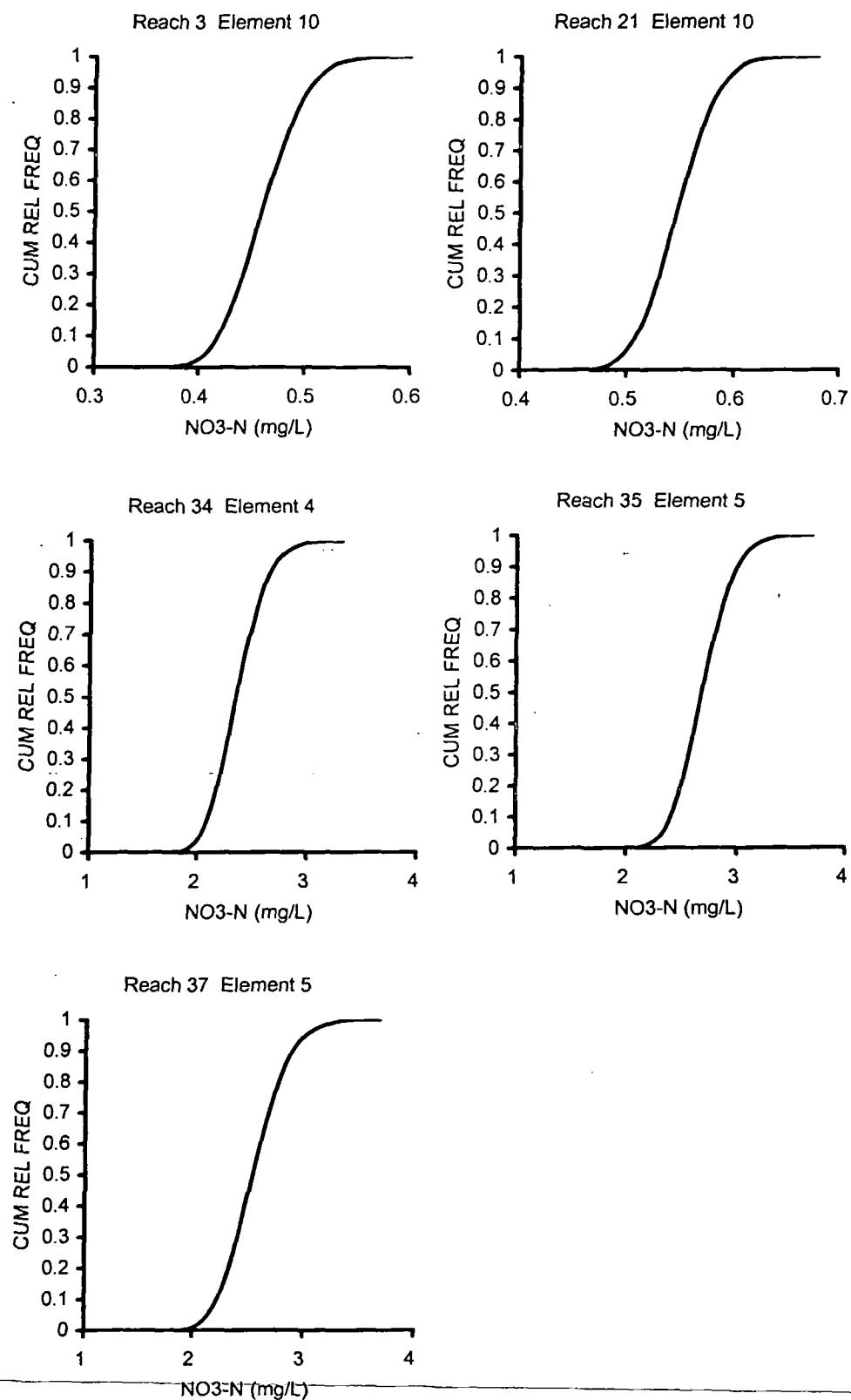


Fig. 26. Cumulative Distribution Function for Nitrate Nitrogen as N

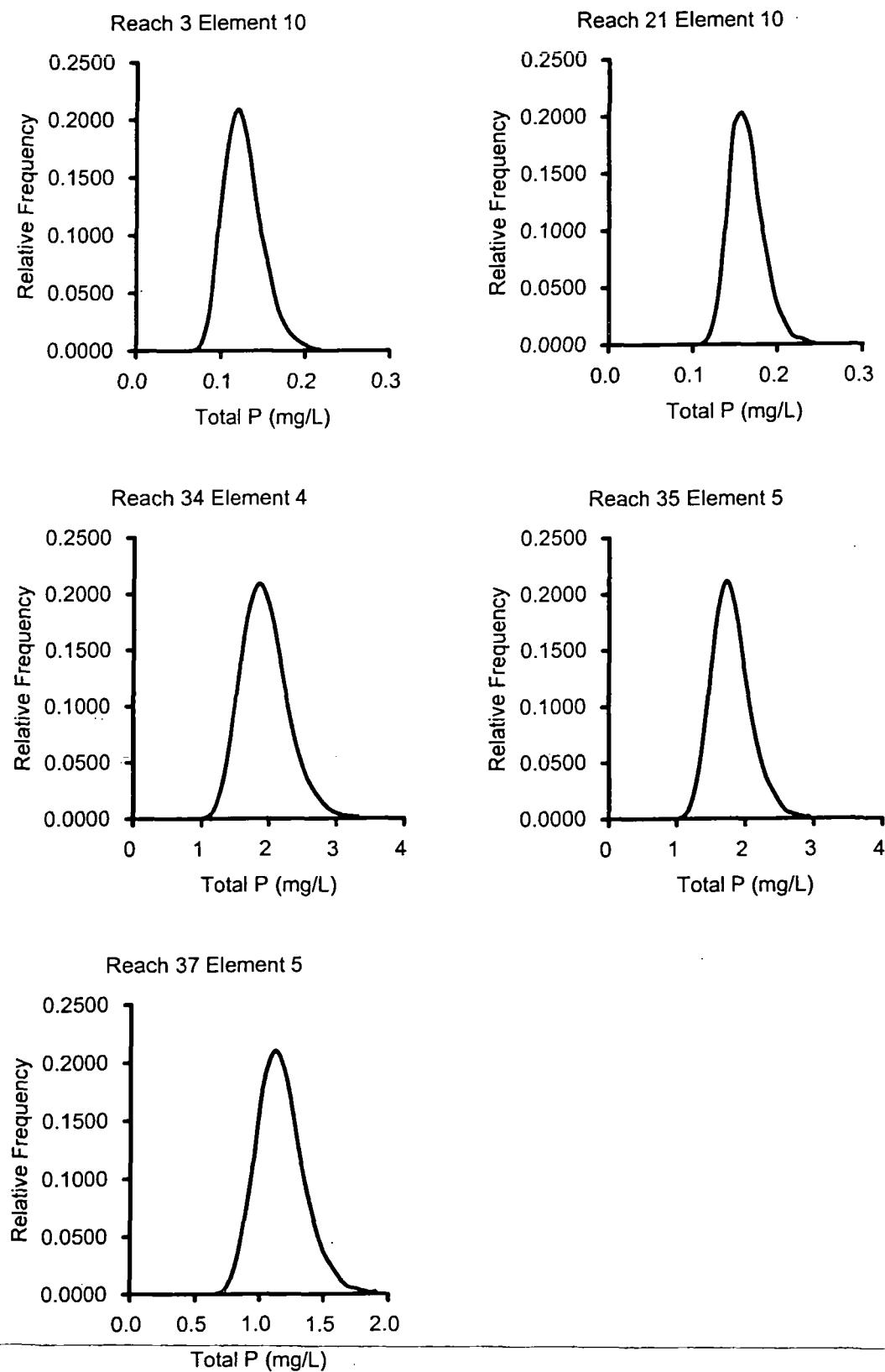


Fig. 27. Frequency Distribution for Total Phosphorus as P

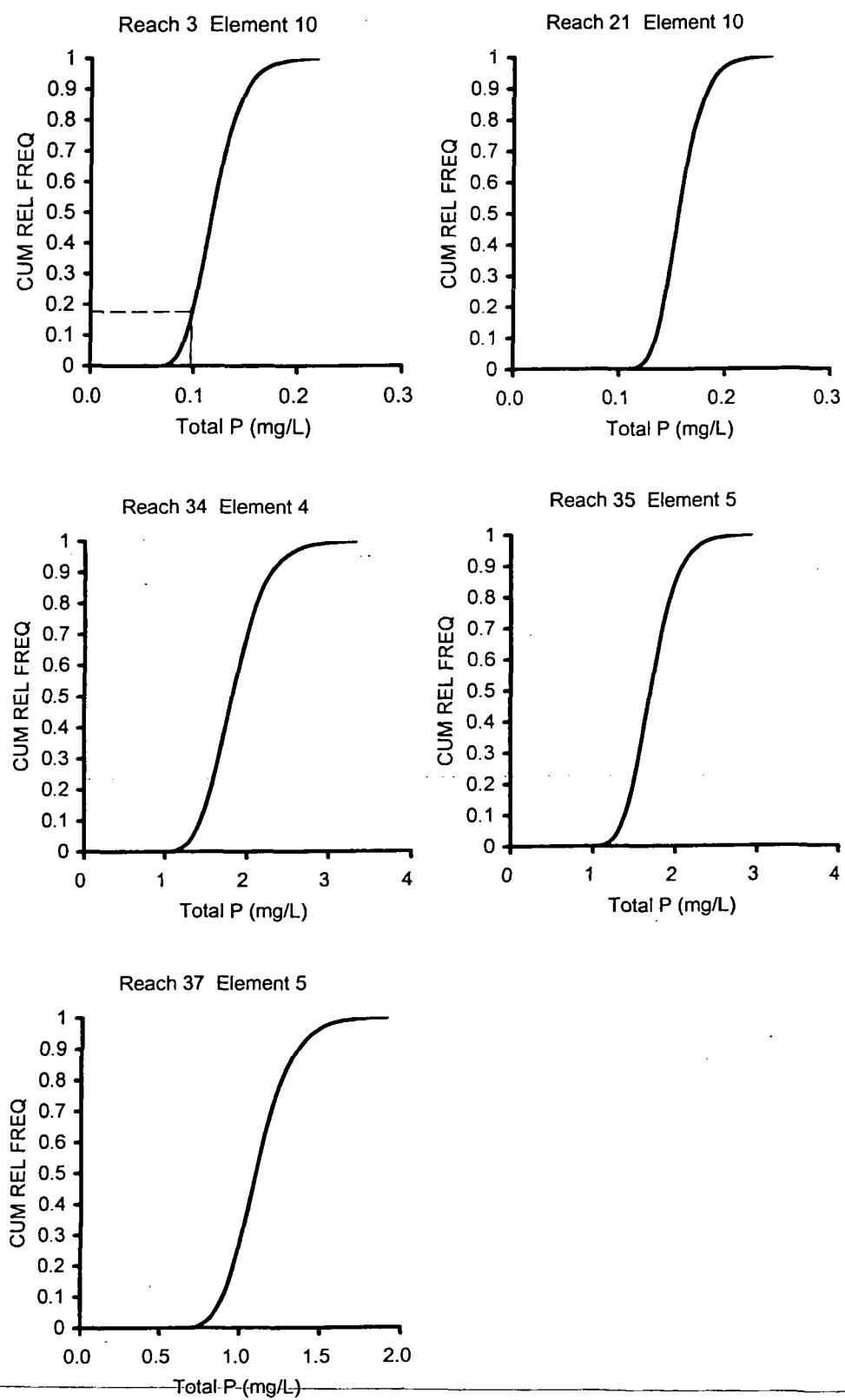


Fig. 28. Cumulative Distribution Function for Total Phosphorus as P

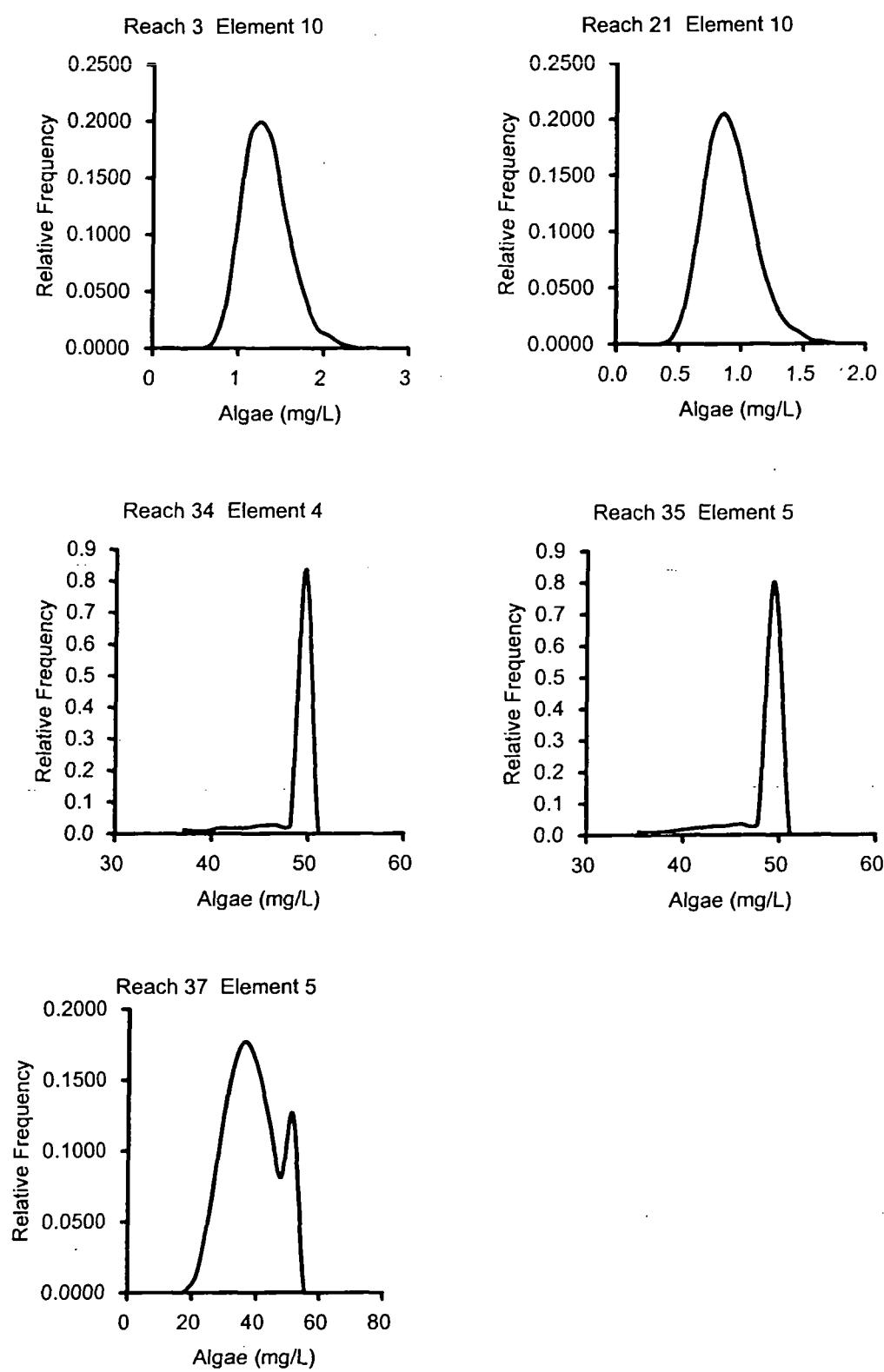


Fig. 29. Frequency Distribution for Algae

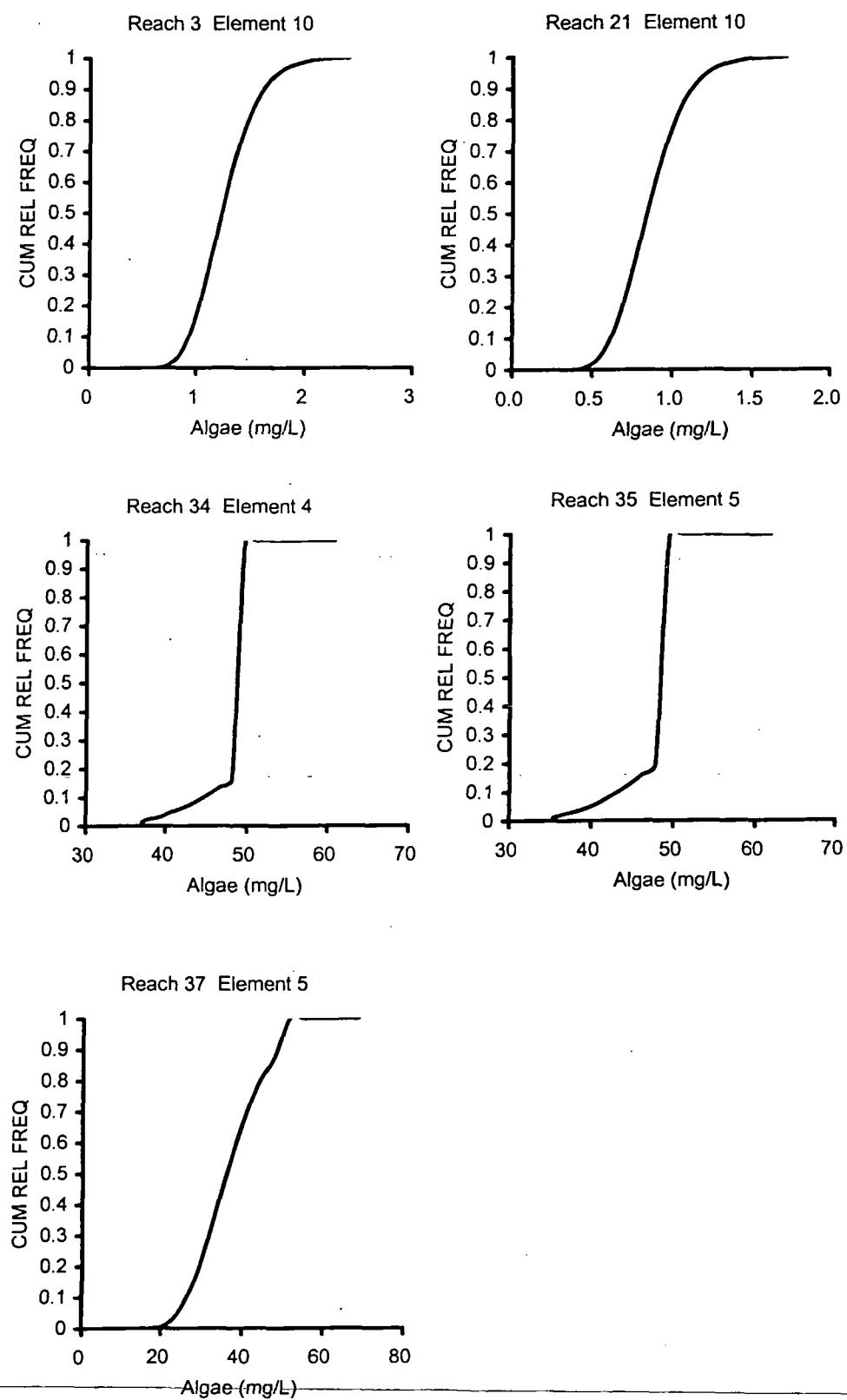


Fig. 30. Cumulative Distribution Function for Algae

solution, ammonia primarily exists in two forms, un-ionized ammonia (NH_3) and ammonium (NH_4^+). NH_3 is much more toxic than NH_4^+ (EPA, 1999). NH_3 is proportional to total ammonia depending on pH and temperature (Kuhn, 1991). The nitrogen target of the Portneuf River TMDL is "Not to exceed 0.3 mg/L as total inorganic nitrogen" (DEQ, 1999a). If this criterion is used as a reference, at 52.3 km (Reach 3 Element 10), and 34.5 km (Reach 21 Element 10), the number of Monte Carlo realizations of $\text{NH}_4\text{-N}$ that occurred below 0.3 mg/L was 100% (see Figure 24). At the junction of the WPC Plant outfall and the river (Reach 34 Element 4, 20.6 km), the number of Monte Carlo realizations of $\text{NH}_4\text{-N}$ that occurred below 0.3 mg/L was 28%. The concentration of $\text{NH}_4\text{-N}$ should exceed 0.3 mg/L, 72% of the time. At the junction of Batiste Springs and the river (Reach 35 Element 5), the number of Monte Carlo realizations of $\text{NH}_4\text{-N}$ that exceed 0.3 mg/L was 100%. At 18.3 km (Reach 37 Element 5), the number of Monte Carlo realizations of $\text{NH}_4\text{-N}$ that occurred below 0.3 mg/L was 92%. The concentration of $\text{NH}_4\text{-N}$ should exceed 0.3 mg/L, 8% of the time.

Nitrate Nitrogen ($\text{NO}_3\text{-N}$). The nitrogen target of the Portneuf River TMDL is "Not to exceed 0.3 mg/L as total inorganic nitrogen" (DEQ, 1999a). the number of Monte Carlo realizations of $\text{NO}_3\text{-N}$ that occurred below 0.3 mg/L was 0% at all the 5 locations. The concentrations of $\text{NO}_3\text{-N}$ should exceed 0.3 mg/L, 100% of the time (see Figure 26). $\text{NO}_3\text{-N}$ is part of inorganic nitrogen (the other two parts are $\text{NH}_4\text{-N}$, and $\text{NO}_2\text{-N}$). Therefore, the concentration of inorganic

nitrogen should exceed 0.3 mg/L 100% of the time.

Total Phosphorus (TOT_P). EPA suggests that "total phosphorus not exceed a concentration of 0.1 mg/L" for prevention of nuisance aquatic growth in streams or flowing waters (DEQ, 1999a). At 52.3 km (Reach 3 Element 10), the number of Monte Carlo realizations of TOT_P that occurred below 0.1 mg/L was 18% (see Figure 28). At other four locations, the number of Monte Carlo realizations of TOT_P that occurred over 0.1 mg/L was 100% (see Figure 28).

The phosphorus target of the Portneuf River TMDL is "Not to exceed 0.075 mg/L as total phosphorus (DEQ, 1999a). The number of Monte Carlo realizations of TOT_P that occurred below 0.075 mg/L was 0% at all 5 locations (see Figure 28). Thus, the concentration of TOT_P should exceed 0.075 mg/L, 100% of the time at all the locations evaluated.

Algae. Algae data instead of algae as chl a were in the output file of Monte Carlo simulation. This is different from the output of calibration part. The conversion is shown in equation (24) in Chapter III. The output data of 5 locations are listed in Table 15.

The Monte Carlo Simulation output showed the warning "Computed algae concentration (chl a) exceeds maximum program constraint (2500 µg/L) in 22 computational elements. Chl a concentration in these elements is set equal to 2500 µg/L." This may have caused the marked negative skewness at Reach 34 Element 4 and Reach 35 Element 5 due to very high chl a concentration that

probably exceed the limitation (2500 µg/L) in these two elements.

Table 15. The Output Data of Model Calibration and Monte Carlo Simulation for Chl a

Location	R3 E10	R21 E10	R34 E4	R35 E5	R37 E5
Chl a of Model Calibration (µg/L)	52.14	35.58	2050	1250	933.83
The Base Mean of Monte Carlo Simulation (mg/L)	1.27	0.87	50	50	37.34
α_0 (µg-chl a / mg-A)	41	41	41	25	25

Note: R3 E10 refers to Reach 3 Element 10, upstream.

R21 E10 refers to Reach21 Element 10, mid-reach.

R34 E4 refers to Reach 34 Element 4, junction of the Portneuf River
and WPC outfall

R35 E5 refers to Reach 35 Element 5, junction of the Portneuf and
Batiste Springs

R37 E5 refers to Reach 37 Element 5, downstream.

CHAPTER VI

DISCUSSION

Using QUAL2E-UNCAS, a one-dimensional, steady-state, water quality model was developed for a 48.2 km stretch of the Portneuf River. The model consists of 40 reaches and 482 computational elements, including 8 tributaries and 6 point sources. The model simulated 13 water quality variables including temperature, BOD_5 , DO, algae, organic-N, ammonia-N, nitrite-N, nitrate-N, organic-P, dissolved-P, total-P, sodium, and chloride.

Water Quality Data Simulation

BOD_5 and DO. The simulated concentrations of BOD_5 and DO in the Portneuf river are shown in Figure 31, from which no apparent relationship between BOD_5 and DO is seen. In general, elevated BOD_5 increases the DO consumption creating DO deficit in the river. However, the simulation results indicate that the level of BOD_5 is not high enough to affect DO in the Portneuf River.

Nitrogen. Figure 32 shows the simulated concentrations of organic-N (ON_N), ammonia-N ($NH4_N$), nitrite-N ($NO2_N$), nitrate-N ($NO3_N$), and total-N (TOT_N). As seen, $NO3_N$ is the most predominant nitrogen species,

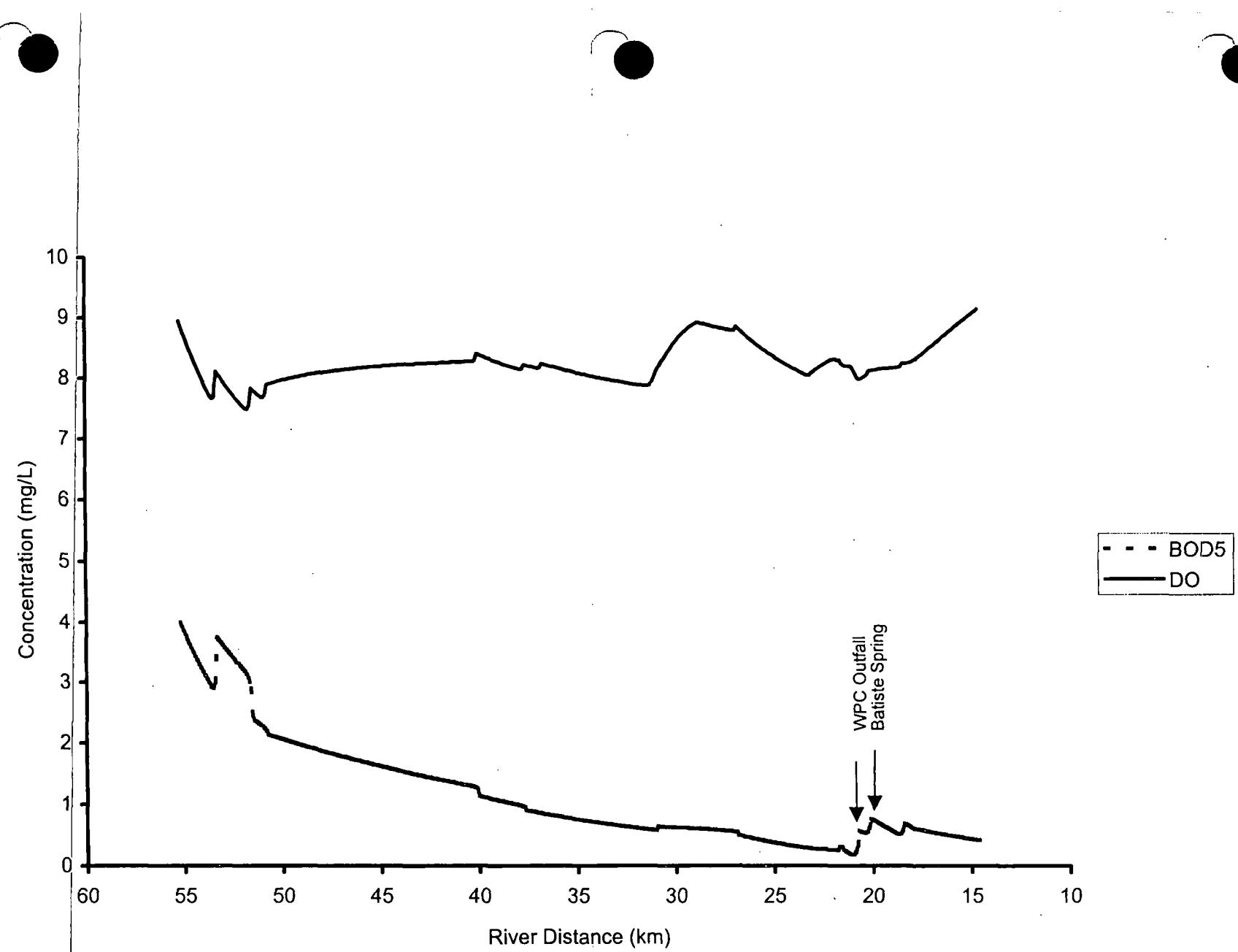


Fig. 31. QUAL2E Simulation Results for BOD_5 and DO in the Portneuf River

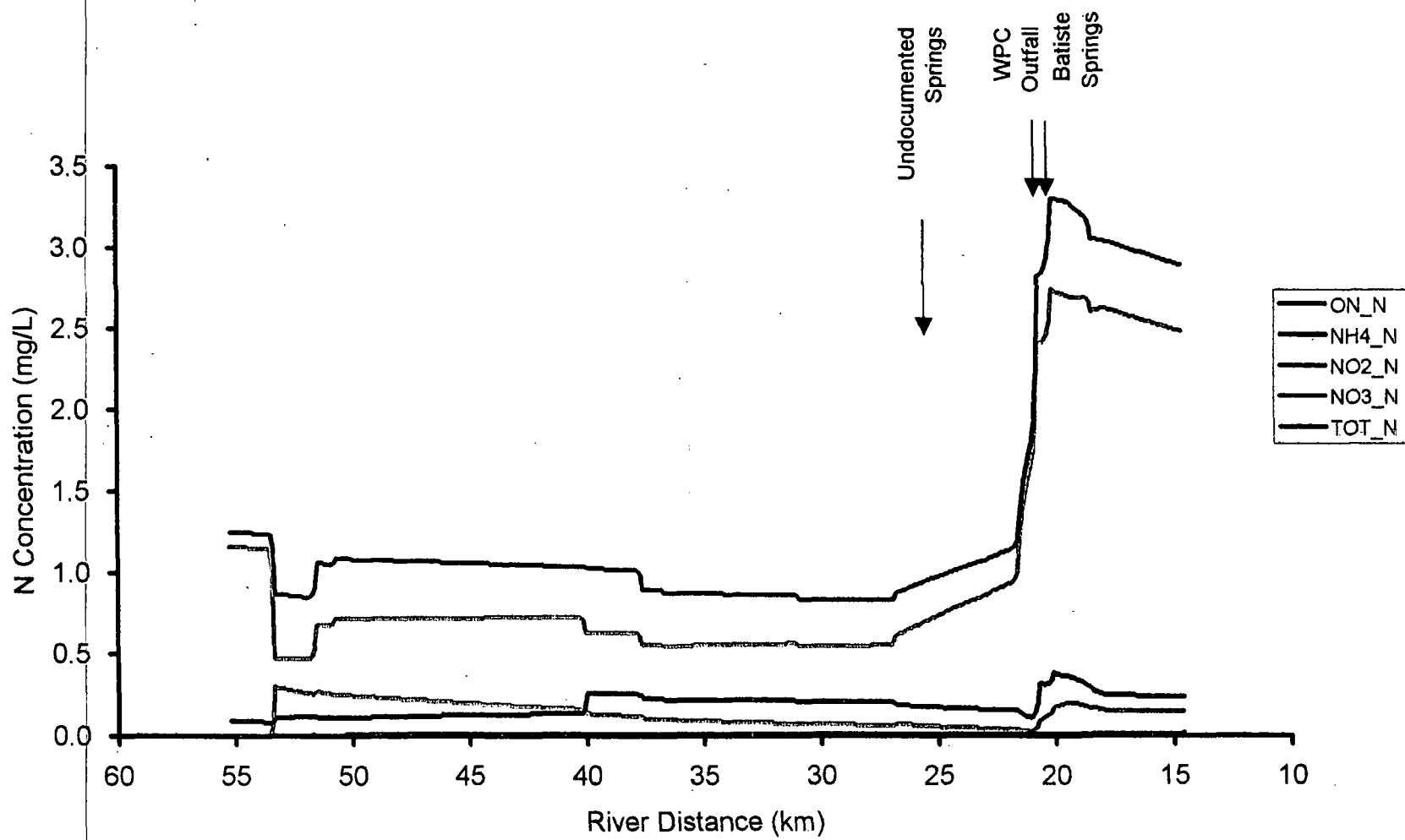


Fig. 32. QUAL2E Simulation Results for Nitrogen Cycle in the Portneuf River

while NO₂_ is insignificant in the river. The reported NO₂_N concentrations range from 0 to 0.02 mg/L. In the river reach from the headwater (55.2 km) to Batiste Rd Bridge (21.5 km), the total nitrogen level is relatively low (~1 mg/L N). The larger flow (0.97 m³/s) and lower concentration of NO₃_N (0.33 mg/L) in Marsh Creek cause a decrease in NO₃_N at 53.3km. The NO₃_N level rises slightly at Rapid Creek (51.5 km) and Indian Creek (50.7 km). Currently, no data are available to verify the model results. The NH₄_N level increases at the junction of the Portneuf River and Mink Creek at 40.0 km. (The cause of the increase in NH₄_N at this location is unknown.)

The nitrogen level starts to increase just upstream from Batiste Rd Bridge (or Swanson Springs). The sharp increase in N occurs at the WPC Plant outfall (20.6 km) and Batiste Springs (20.0 km) located between Batiste Rd Bridge (21.5 km) and Siphon Rd Bridge (17.8 km).

NH₄_N increases at the WPC Plant outfall and Batiste Springs, but only slightly. Nitrate slowly decreases in the down stream reach between 20.6 and 20.0 km due probably to the numerous undocumented springs containing lower N concentrations.

The nitrogen loadings from various sources to the Lower Portneuf River were computed based on mass balance. Summary results are shown in Figure 33 and illustrated in Figure 34. The mass balance calculations are shown in Appendix H. The results indicate that the Pocatello WPC Plant is the largest

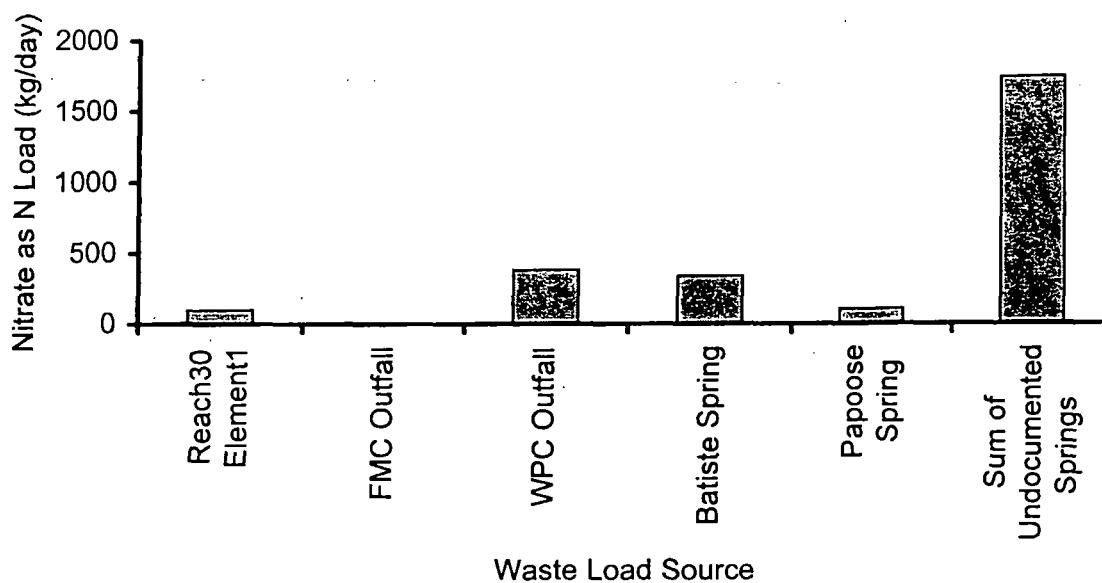
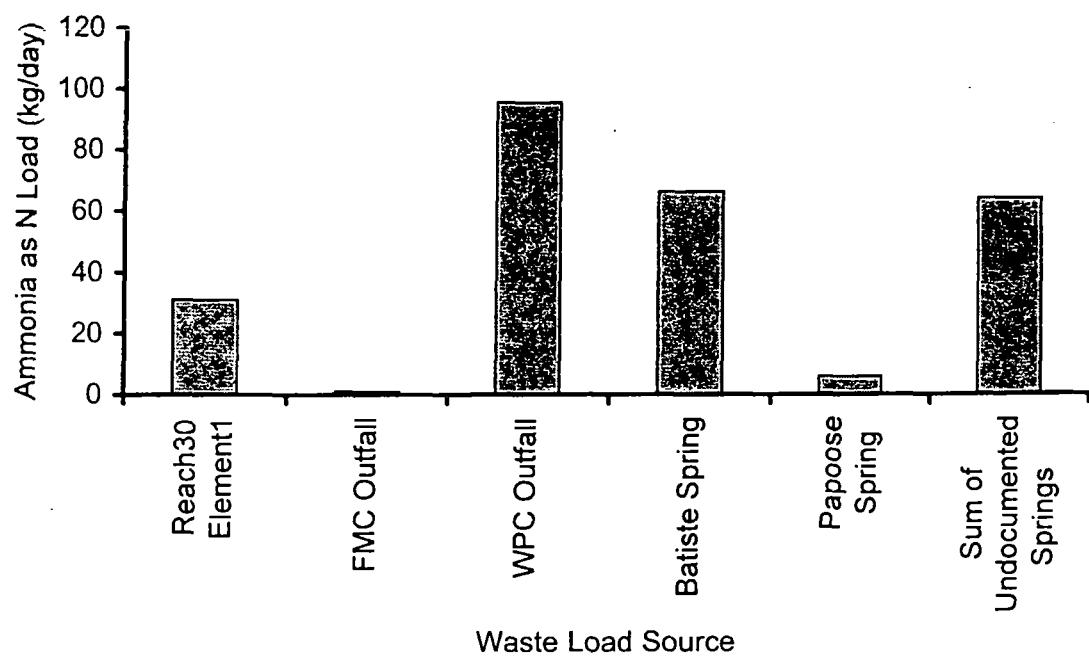


Fig.33. Ammonia as N and Nitrate as N Load in the Lower Portneuf River

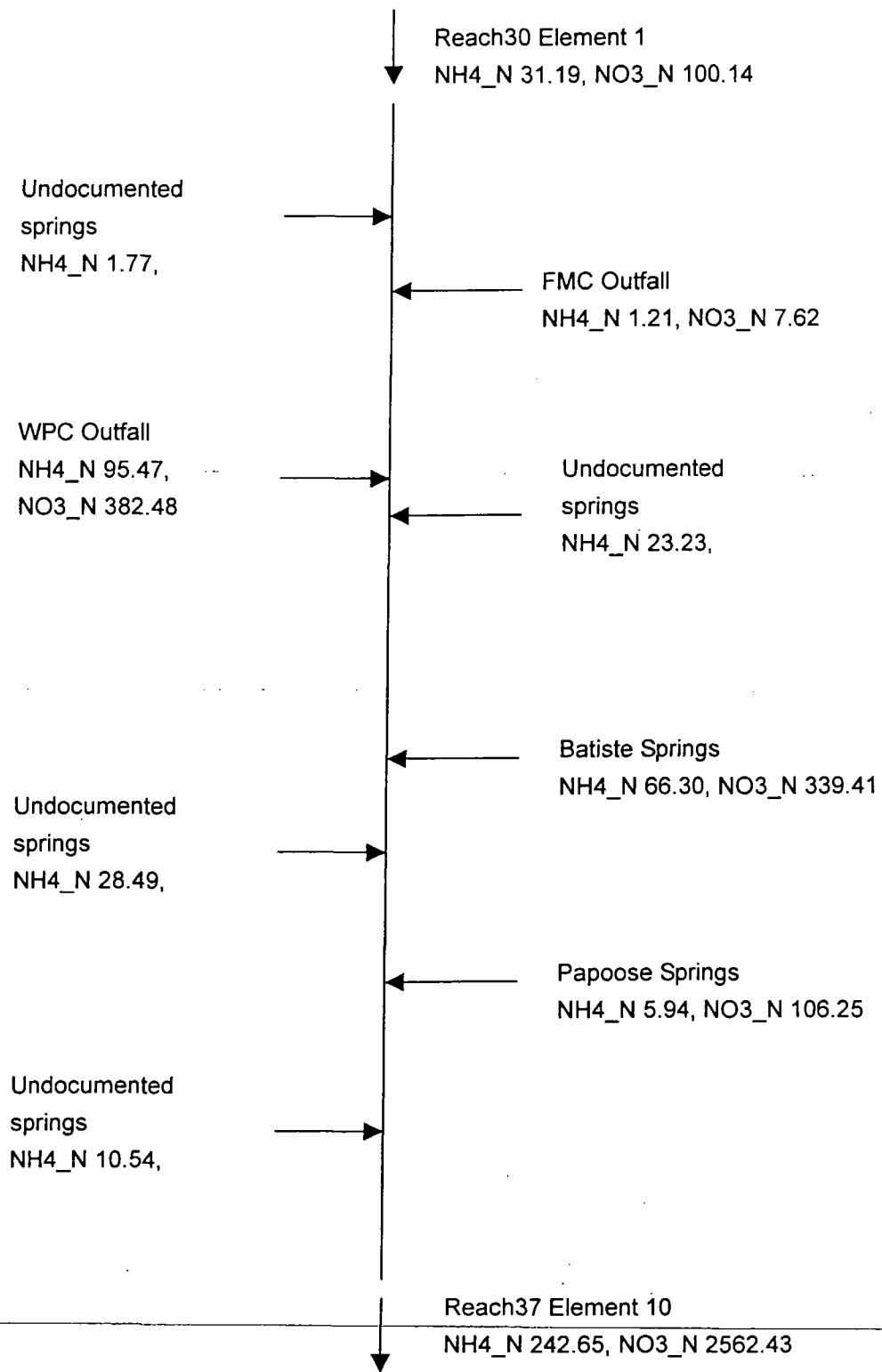


Fig. 34. Nitrogen Loadings to the Lower Portneuf River
(Unit: kg/day)

contributor of NH₄-N to the Portneuf River with an estimated NH₄-N loading of 95 kg N/day. The second largest source of NH₄-N is Batiste Springs (66 kg N/day). On the other hand, the largest NO₃-N loading (1744 kg N/day) is from unknown sources (i.e., undocumented springs and groundwater discharges). The NO₃-N loading from WPC Plant is estimated to be approximately 380 kg N/d. It should be noted that the NO₃-N concentrations are lower in Papoose Springs and undocumented springs/groundwater discharges than in the WPC Plant outfall, and that the amount of discharges from undocumented springs/groundwater are considerably larger than that from the WPC. The higher discharges from the undocumented springs/groundwater result in the larger NO₃-N loading. Due to the high NO₃-N loadings between the WPC and Siphon Rd Bridge, the NO₃-N concentration remains high in this region of the river.

Phosphorus. The simulated concentrations of total phosphorus (TOT_P), dissolved phosphorus (DIS_P), and organic phosphorus (ORG_P), and chl a are shown in Figure 35. The phosphorus levels in the river above Batiste Rd Bridge (21.5 km) remain low and static. The concentration trend of DIS_P is similar to that of TOT_P. Similar to nitrogen, phosphorus levels increase dramatically in the river reach between Batiste Rd Bridge (21.5 km) and Siphon Rd Bridge (17.8 km). The considerable increase in phosphorus concentrations is most likely due to the WPC outfall (20.6 km), Batiste Springs (20.0 km), and other undocumented springs. Figures 36 and 37 show the estimated total phosphorus loadings to the

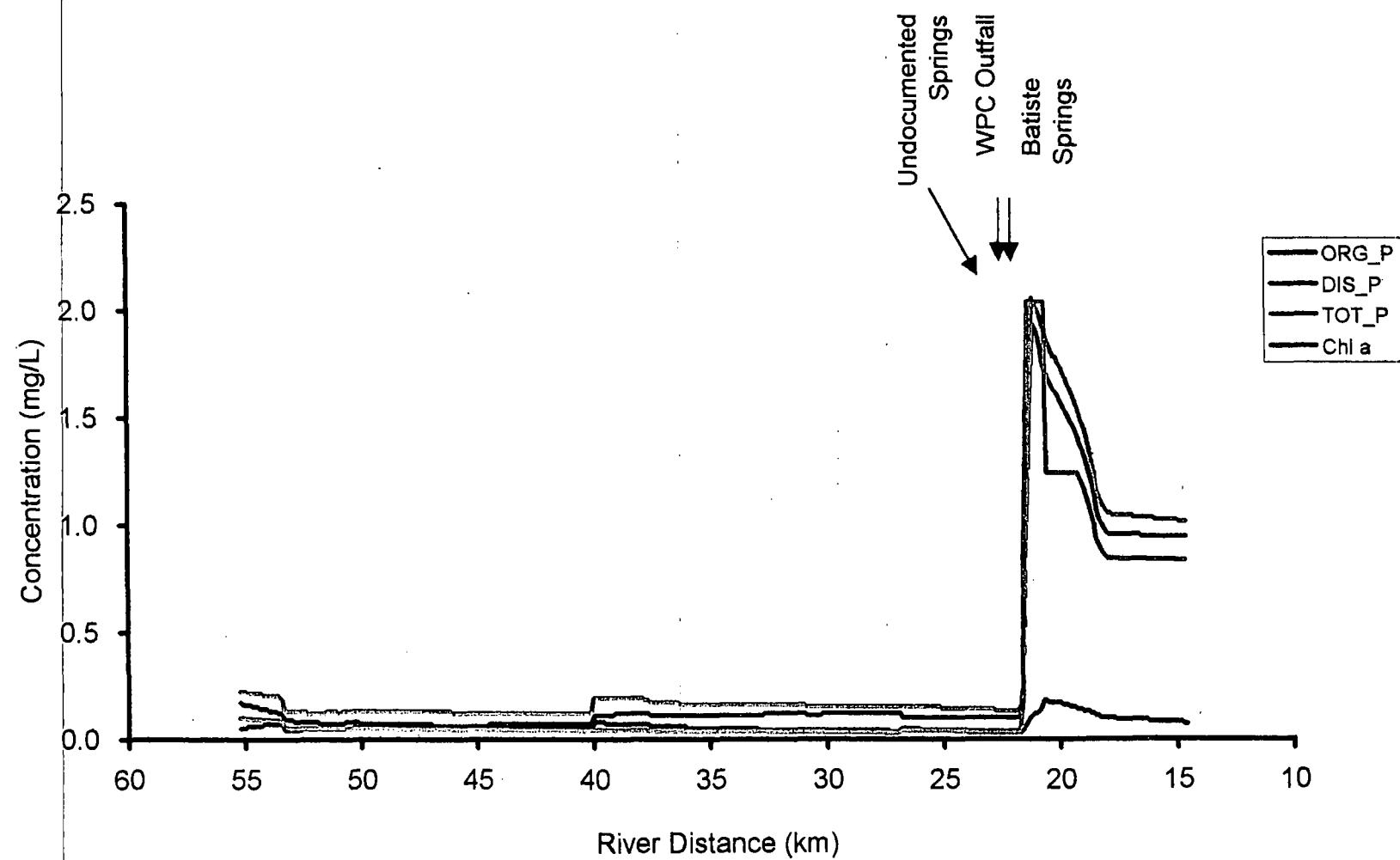


Fig. 35. QUAL2E Simulation Results for Phosphorus Cycle and Algae as Chlorophyll a in the Portneuf River

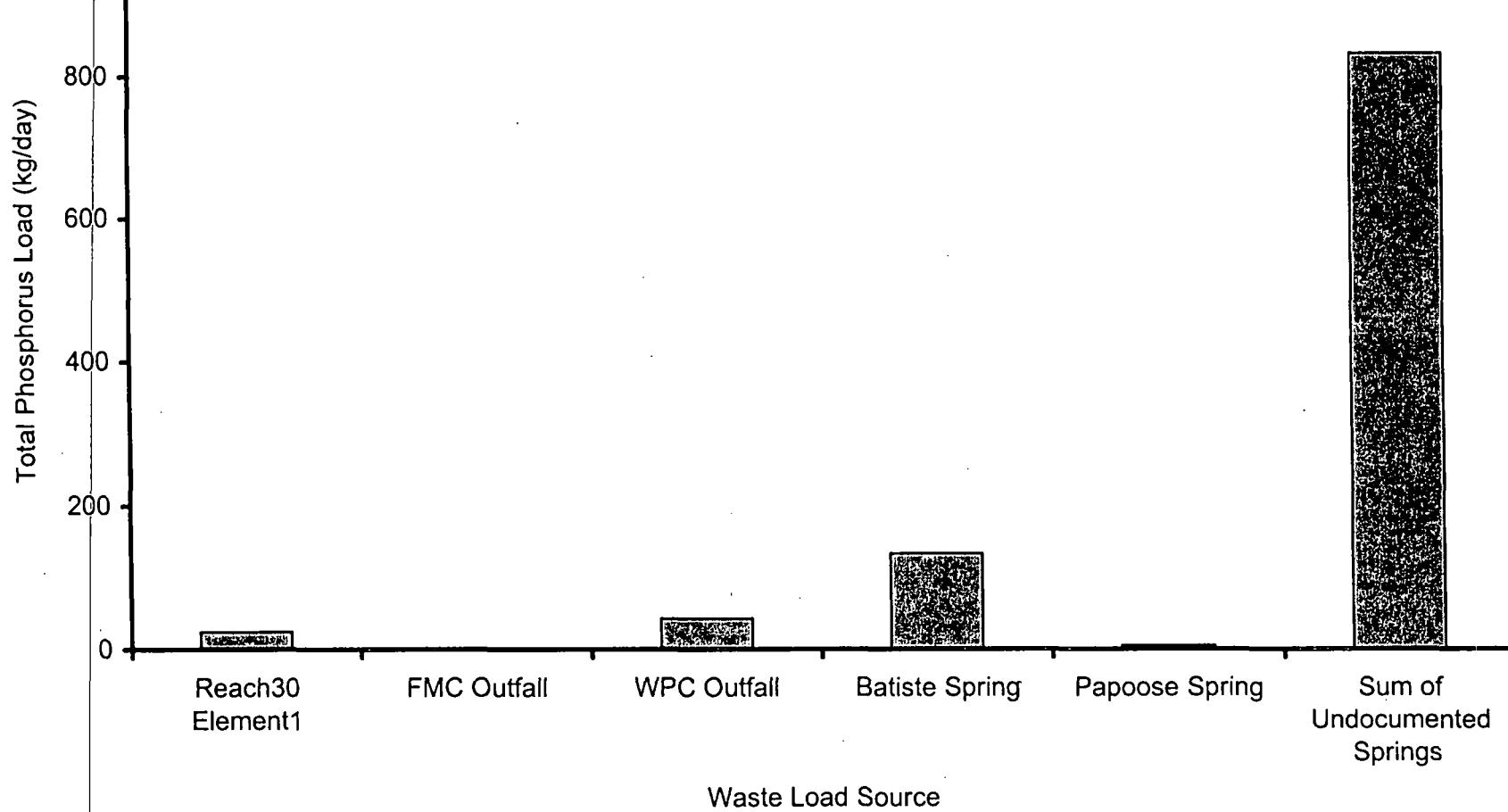


Fig. 36. Total phosphorus as P Load in the Lower Portneuf River

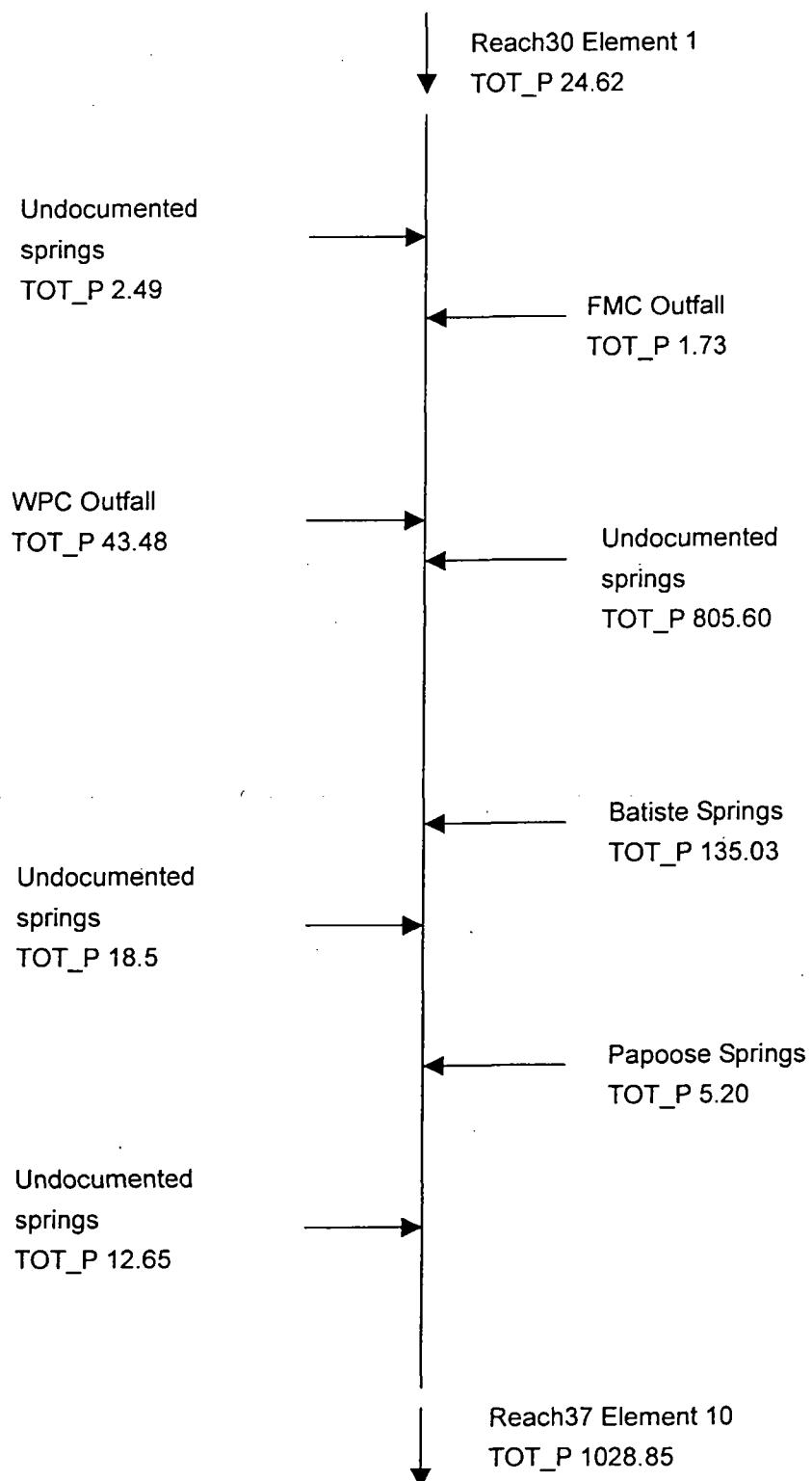


Fig. 37. Total Phosphorus Loadings to the Lower Portneuf River (Unit: kg/day)

river between 26.8 km (Reach 30 Element 1) and Siphon Rd Bridge at 17.8 km (Reach 37 Element 10). The mass balance calculations are shown in Appendix H. As seen, the numerous undocumented springs and/or groundwater discharges are the largest contributor of TOT_P to the Lower Portneuf River. The estimated total phosphorus loading from undocumented springs is 839 kg P/day.

Conservative Elements: Chloride (Cl) and sodium (Na) were selected as conservative elements for the QUAL2E simulation of the Portneuf River. Model results for Cl and Na are shown in Figure 38, which indicates that the WPC outfall and Batiste Springs are the major sources of Cl to the river. The marked changes in Cl concentrations are predicted at the junctions of the river and tributaries: Marsh Creek (53.3 km), Rapid Creek (51.5 km), Indian Creek (50.7 km), Mink Creek (40.0 km), Gibson Jack Creek (37.6 km), Johnny Creek (36.7 km), City Creek (30.9 km), and Pocatello Creek (26.8 km). These changes are due to the concentration difference between the river and the tributaries. Simulated Na concentration (Figure 38) was very similar to the simulated Cl concentration.

QUAL2E Simulations for Hypothetical Scenarios

The calibrated Portneuf River model was used to simulate NH4_N, NO3_N, ORG_P, DIS_P, TOT_P and chl_a for the following four "What-if" scenarios:

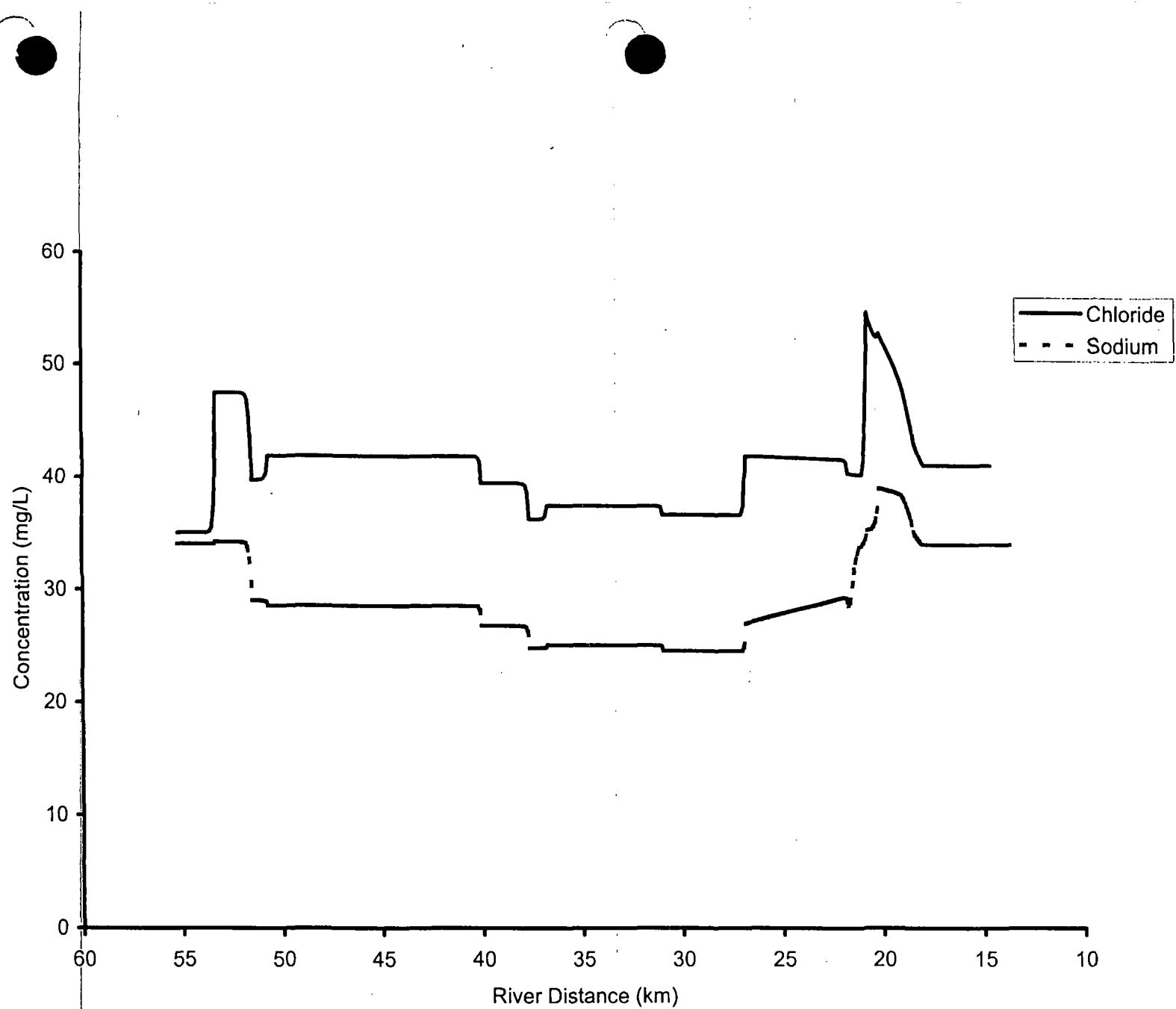


Fig. 38. QUAL2E Simulation Results for Chloride and Sodium in the Portneuf River

- 1) if Pocatello WPC Plant is upgraded with an ideal nitrification process,
- 2) if Pocatello WPC Plant is upgraded with an ideal nitrification-denitrification process,
- 3) if Pocatello WPC Plant is upgraded with an ideal phosphorus removal process.
- 4) if Pocatello WPC Plant is upgraded with an ideal nitrification-denitrification process combined with an ideal phosphorus removal process.

Using the current condition as the no-action (baseline) scenario, model simulation result from each scenario is examined.

Scenario 1: Enhancement of Pocatello WPC with an Ideal Nitrification Process. In this scenario, all ammonia-N is oxidized to nitrate-N. Therefore, NH₄_N in the WPC Plant outfall is 0 mg/L, and NO₃_N in the outfall becomes baseline NH₄_N plus baseline NO₃_N. Figure 39 shows the predicted concentrations of NH₄_N, NO₃_N, and chl a. The peak concentration of NH₄_N is decreased 41%, from 0.39 mg/L to 0.23 mg/L, while NO₃_N is slightly increased from 2.74 to 2.9 mg/L. The concentration of algae (chl a) is unchanged; thus the nitrification process would not improve the current eutrophication level (measured as chl a) of the Lower Portneuf River.

Scenario 2: Enhancement of Pocatello WPC with an Ideal Nitrification-Denitrification Process. In this scenario, both ammonia-N and nitrate-N are

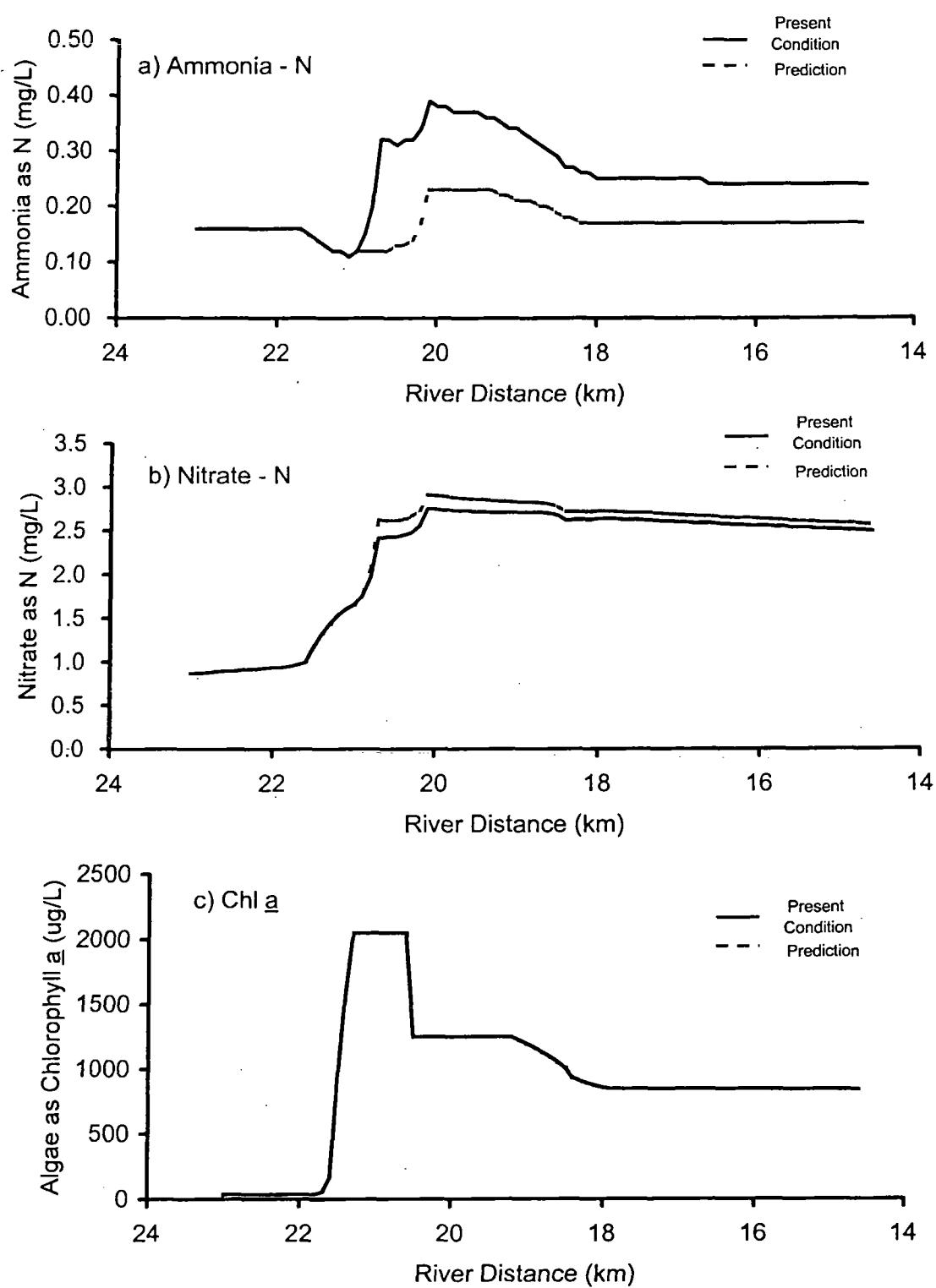


Fig. 39. Scenario 1: Enhancement of Pocatello WPC with an Ideal Nitrification Process

completely removed from the WPC Plant outfall (i.e., NH₄_N = 0 mg/L, NO₃_N = 0 mg/L). The model simulation results are shown in Figure 40. As shown, the peak concentration of NH₄_N decreased by 41% (from 0.39 mg/L to 0.23 mg/L), and that of NO₃_N decreased by 23% (from 2.74 to 2.11 mg/L). However, the concentration of algae (chl a) is predicted to be unchanged, indicating that the nitrification-denitrification process would not improve the current eutrophication level of the Lower Portneuf River.

Scenario 3: Enhancement of Pocatello WPC with an Ideal Phosphorus Removal Process. In this scenario, total phosphorus is completely removed from the WPC Plant outfall (i. e., ORG_P = 0 mg/L, and DIS_P = 0 mg/L). The predicted results are shown in Figures 41 and 42. As is seen in Figure 41, the peak concentration of ORG_P decreased by 33% (0.18 mg/L to 0.12 mg/L). However, there are insignificant reductions of DIS_P, TOT_P, and chl a in the river (Figures 41 and 42). The results suggest that the phosphorus removal in WPC would not improve the current level of eutrophication in the Lower Portneuf River.

Scenario 4: Enhancement of Pocatello WPC with Ideal Nitrification-Denitrification Process and Phosphorus Removal Process. In this scenario, ammonia-N, nitrate-N, and total-P are completely removed from the WPC Plant outfall (i. e., NH₄_N = 0 mg/L, NO₃_N = 0 mg/L, ORG_P = 0 mg/L, and DIS_P = 0 mg/L). Model simulation results are shown in Figures 43 and 44. The peak

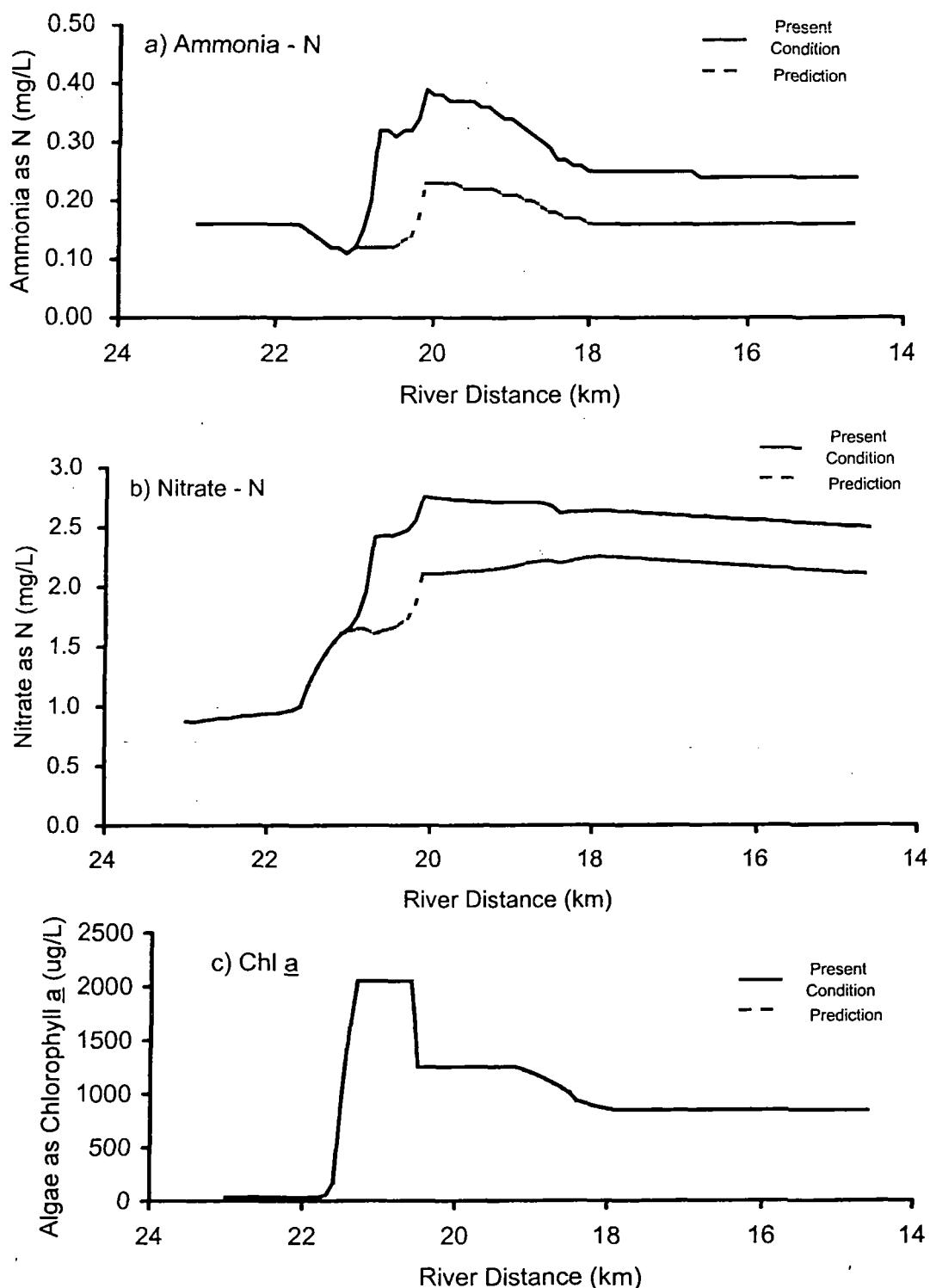


Fig.40. Scenario 2: Enhancement of Pocatello WPC with an Ideal Nitrification - Denitrification Process

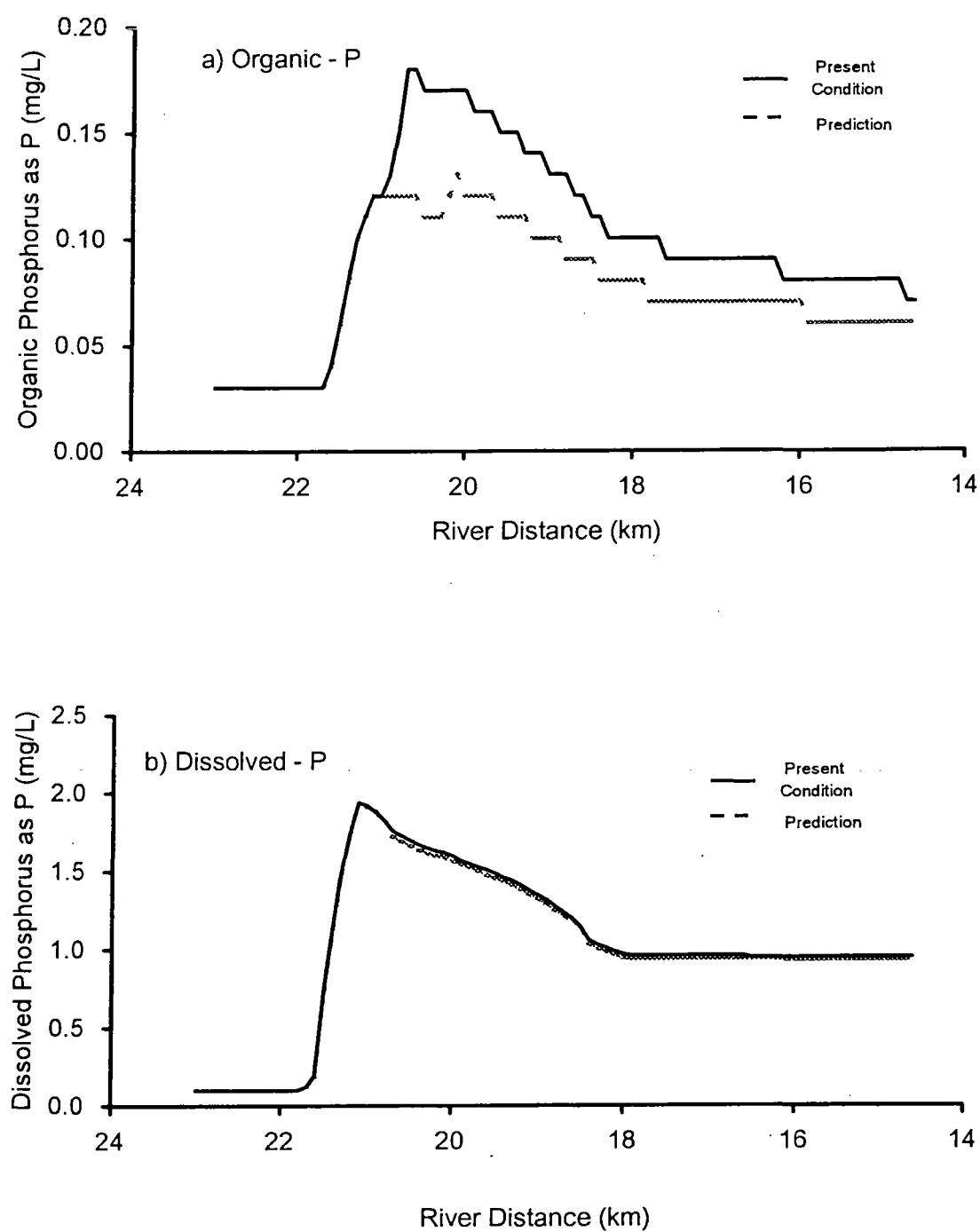


Fig. 41. Scenario 3: Enhancement of Pocatello WPC with an Ideal Phosphorus Removal Process: Effects on a) Organic-P, and b) Dissolved-P

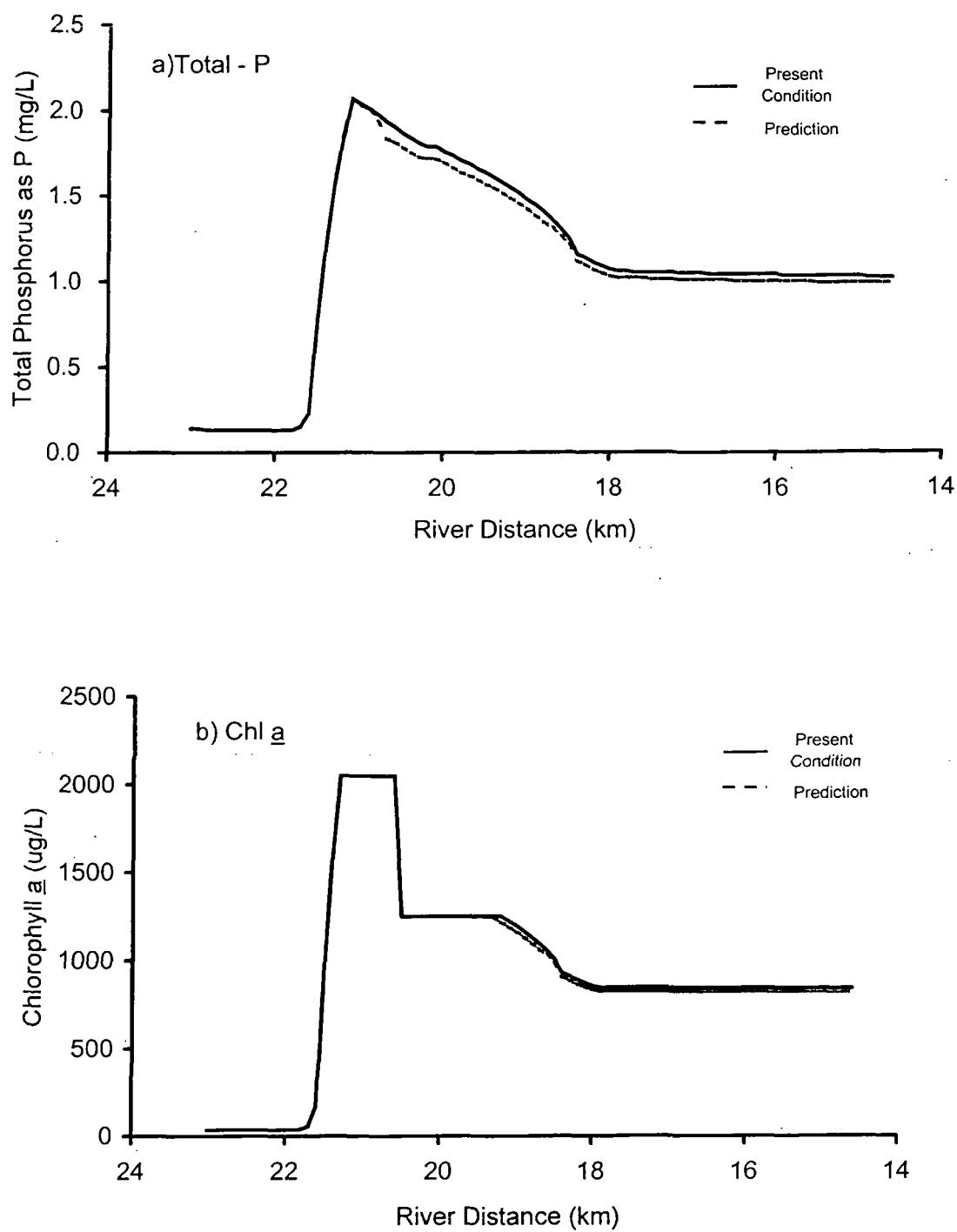


Fig. 42. Scenario 3: Enhancement of Pocatello WPC with an Ideal Phosphorus Removal Process : Effects on a) Total - P, and b) Chl a

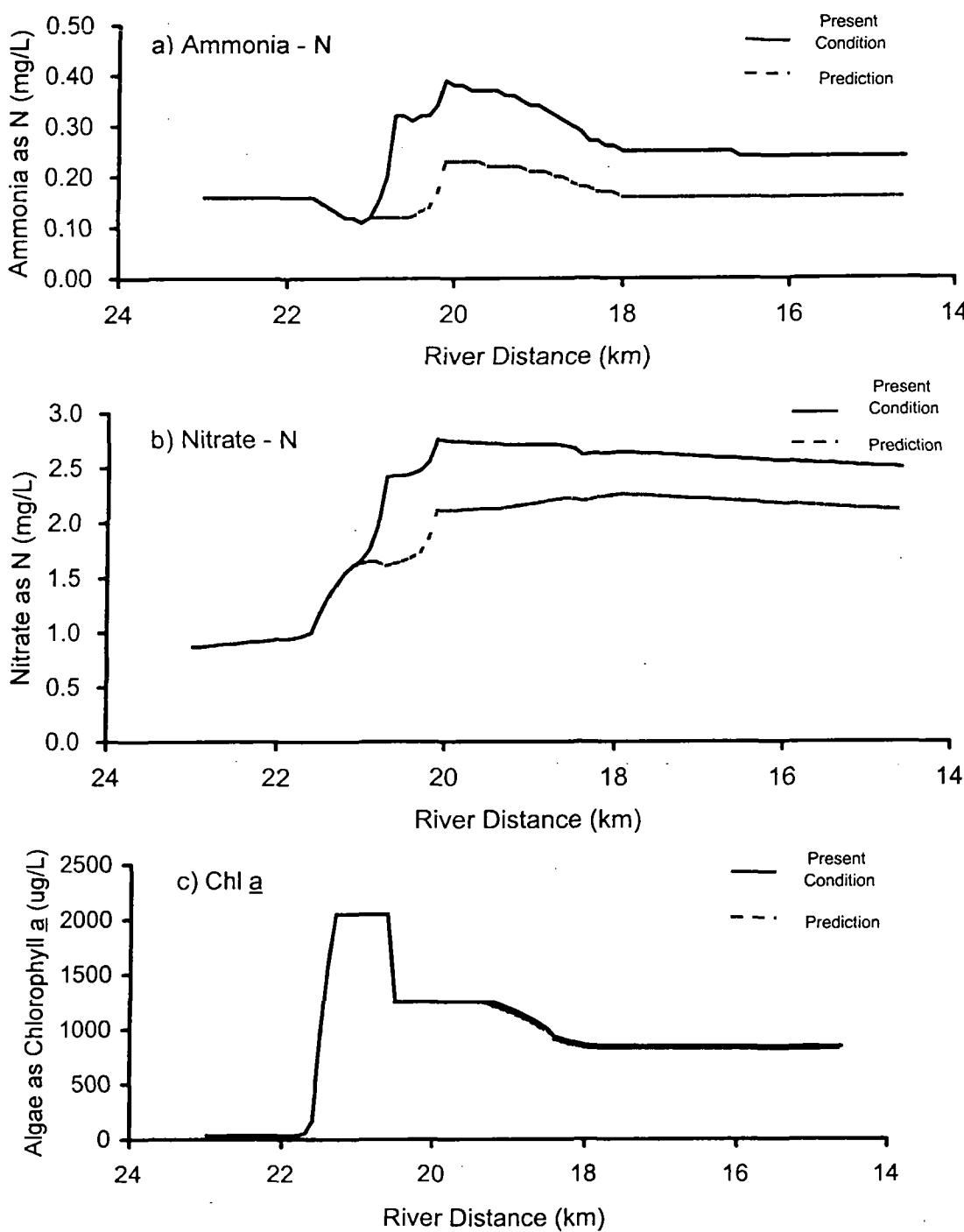


Fig. 43. Scenario 4: Enhancement of Pocatello WPC with Ideal Nitrification-Denitrification and Phosphorus Removal Process: Effects on a) Ammonia-N, b) Nitrate-N, and c) Chl α in the Portneuf River

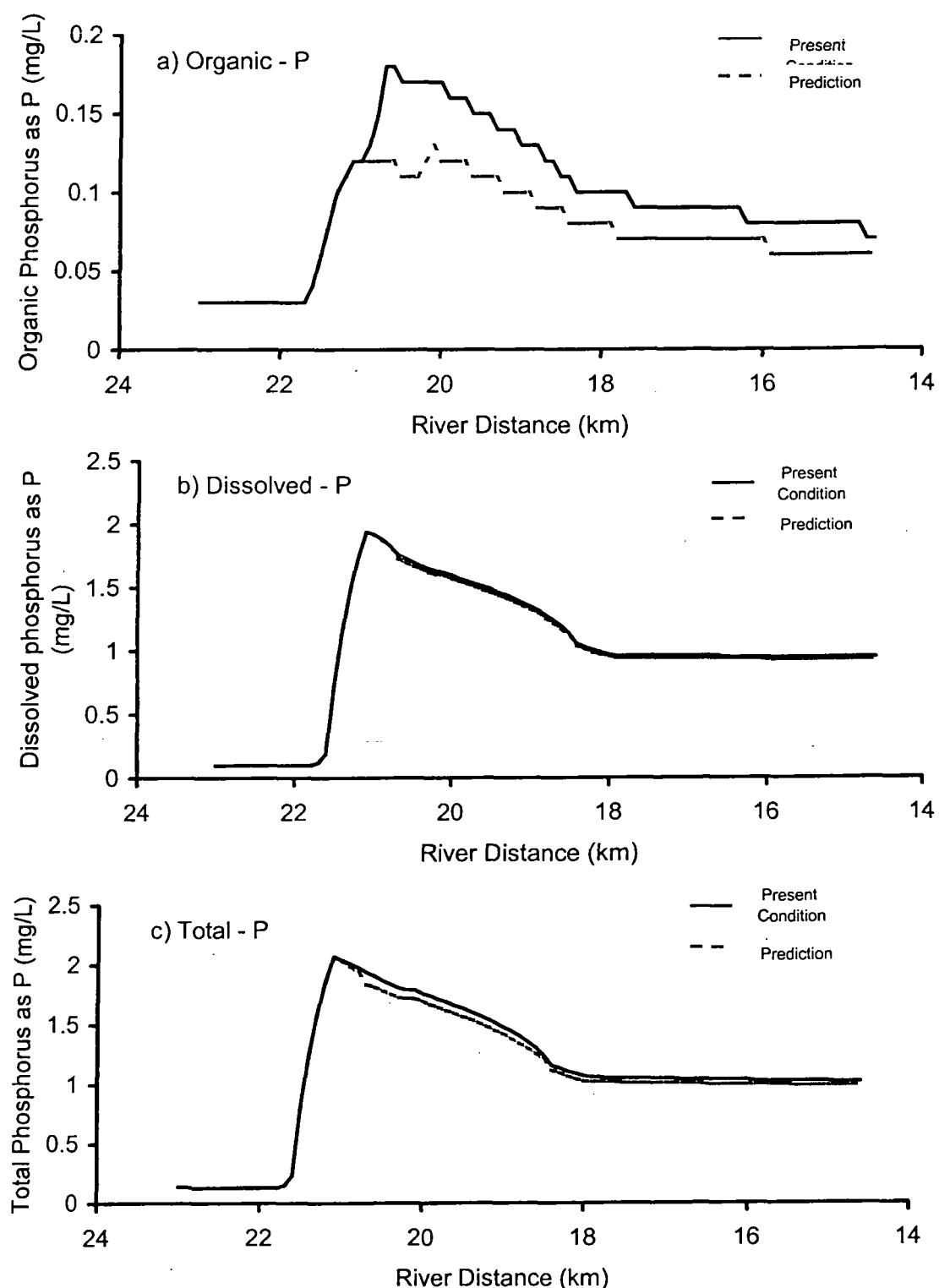


Fig. 44. Scenario 4: Enhancement of Pocatello WPC with Ideal Nitrification-Denitrification and Phosphorus Removal Process:
Effects on a) Organic-P, b) Dissolved -P, and c) Total -P in the Portneuf River

concentration of NH₄_N decreased by 41% from 0.39 to 0.23 mg/L, and that of NO₃_N decreased by 23% from 2.74 to 2.11 mg/L (Figure 43). The peak concentration of ORG_P decreased 33% from 0.18 mg/L to 0.12 mg/L (Figure 44). The changes of the DIS_P and TOT_P concentrations are insignificant (Figure 44). The concentration of chl a is not sensitive to the WPC Plant nutrient loading, indicating that the nitrification-denitrification combined with phosphorus removal process would not improve the current level of eutrophication (measured as chl a) in the Lower Portneuf River.

CHAPTER VII

CONCLUSION AND RECOMMENDATION

Conclusions

Based on the calibration and uncertainty analysis using the recent data, the results from the simulation of the Portneuf River water quality model have led to the following conclusions:

1. Within the study area (from 55.2 km to 13.5 km), the number of Monte Carlo realizations of the concentration of total inorganic nitrogen (as N) that occur exceeding the TMDL nutrient target (0.3 mg/L) is 100%.
2. The number of Monte Carlo realizations of ammonia-N concentration that occur exceeding 0.3 mg/L is 72% at the junction of the Portneuf River and the WPC Plant outfall (Reach 34 Element 4); and 100% at the junction of the Portneuf River and Batiste Springs (Reach 35 Element 5).
3. Within the study area, the number of Monte Carlo realizations of the concentration of total phosphorus (as P) that occur exceeding the TMDL nutrient target (0.075 mg/L) is 100%. The high levels of algae (as chlorophyll a) between Batiste Rd Bridge (21.5 km) and 13.5 km indicate the eutrophication of the lower Portneuf River.

4. The concentration of BOD_5 is not high enough to affect the DO level in the Portneuf River.
5. The number of Monte Carlo realizations of the day time DO concentration that occur exceeding 6.0 mg/L is 100%.
6. Pocatello WPC Plant outfall is the largest ammonia-N (NH_3-N) contributor to the lower Portneuf River. The NH_3-N loading from WPC Plant is estimated to be 95 kg/day, but considerably smaller than the NO_3-N loading (380 kg N/d.).
7. Batiste Springs and other undocumented springs are impacting the water quality (N, P) of the river. The ammonia-N loading from Batiste Springs is 66 kg/day.
8. The numerous springs and groundwater discharge between Batiste Rd Bridge (21.5km) and Siphon Rd Bridge (17.8km) are the largest nitrate nitrogen (NO_3-N) and total phosphorus (TOT_P) contributors to the river. The estimated nitrate-N and total phosphorus-P loadings from the undocumented springs and groundwater discharges are 1744 kg N/day and 839 kg P/day, respectively.
9. Based on the hypothetical Scenarios, the following conclusions can be achieved:
 - a. If Pocatello WPC Plant was upgraded with an Ideal nitrification or nitrification-denitrification process, ammonia-N concentration

decreases by 41% at the junction of the WPC Plant outfall and the Portneuf River. The nitrification process alone would slightly increase nitrate-N concentration in the river. The nitrification-denitrification process would decrease nitrate-N concentration by 23%. Neither the nitrification nor the nitrification-denitrification process would affect the growth of algae, thus eutrophication of the Portneuf River.

- b. An Ideal phosphorus removal process or nitrification-denitrification combined with phosphorus removal process would decrease organic-P by 33%, but give insignificant effects on dissolved-P, total-P, and algae (as chlorophyll a).

Recommendations

1. To build a robust Portneuf River model, the model verification needs to be performed when new data sets are available.
2. Nutrient (N, P) and flow data from known springs including Swanson, Batiste, and Papoose are lacking. These data are needed to evaluate the effect of springs on the Portneuf River water quality.
3. Nutrient (N, P) data in Marsh Creek, Mink Creek, Rapid Creek, and Indian Creek are needed to calibrate the upper reaches of the model.

4. Undocumented springs need to be identified and characterized in terms of flow and nutrient concentrations, which have the most effect on the Lower Portneuf River water quality.
5. Dynamic modeling of the river is recommended to gain insight into temporal changes in water quality of the Portneuf River.

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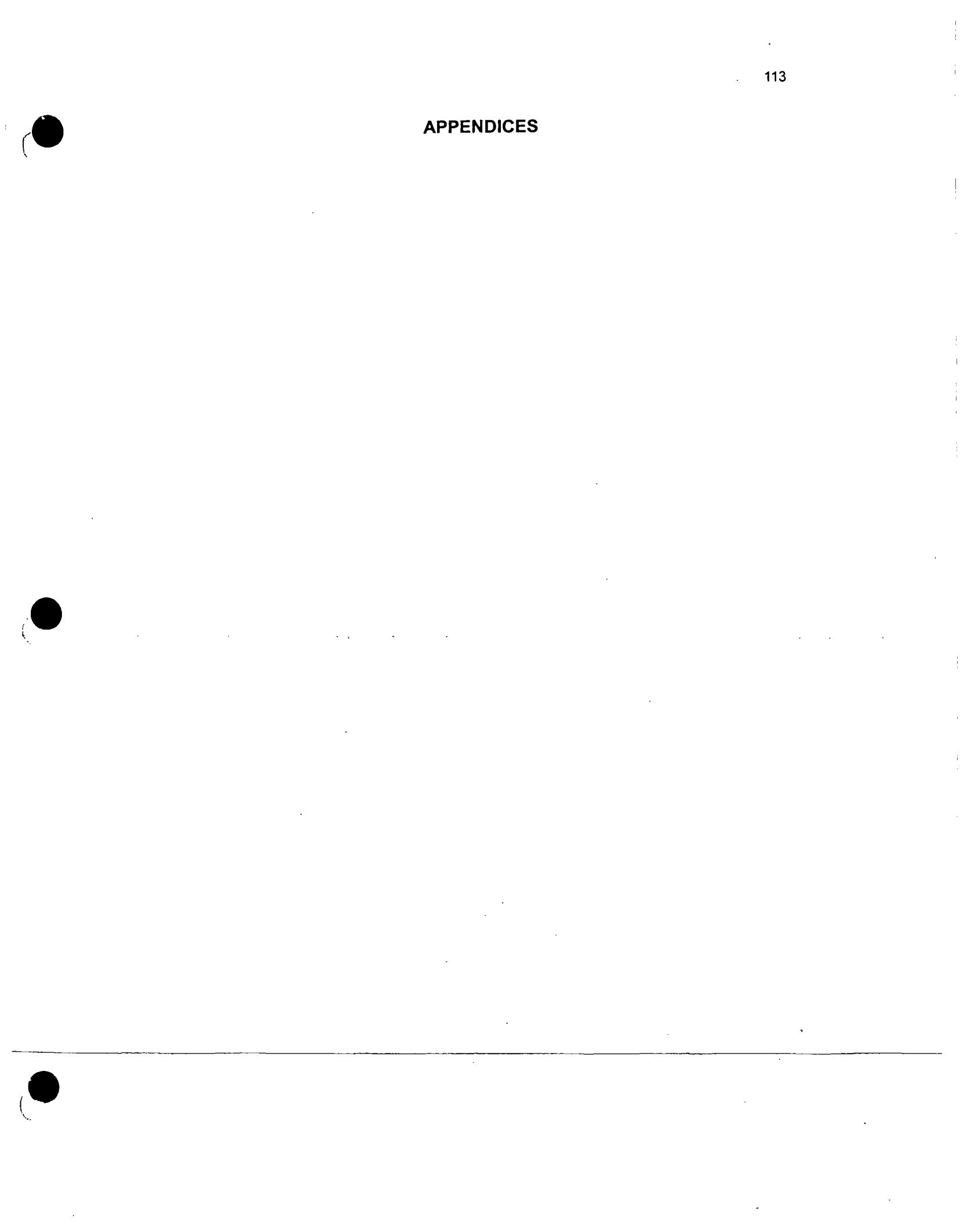
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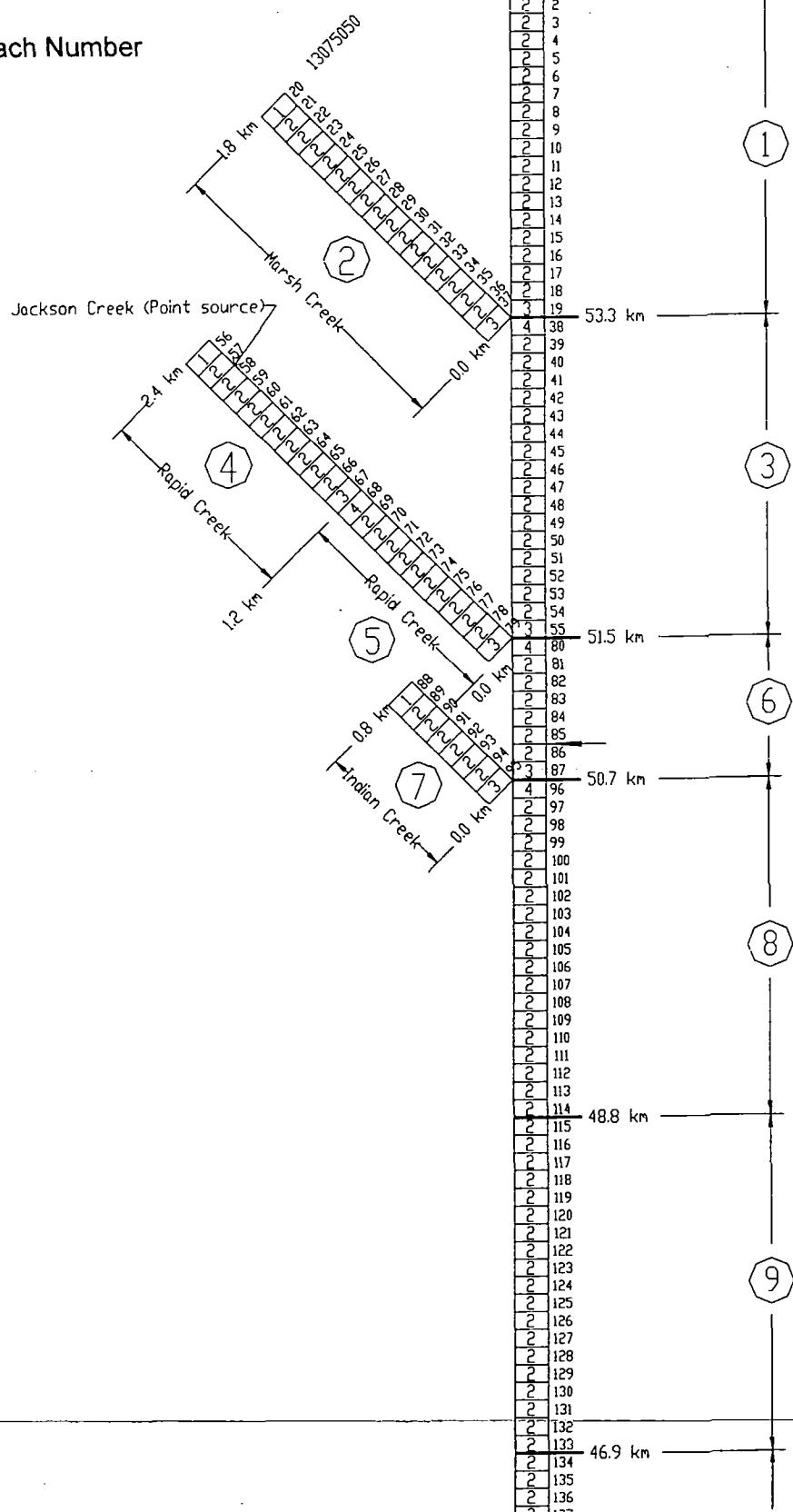
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APPENDICES

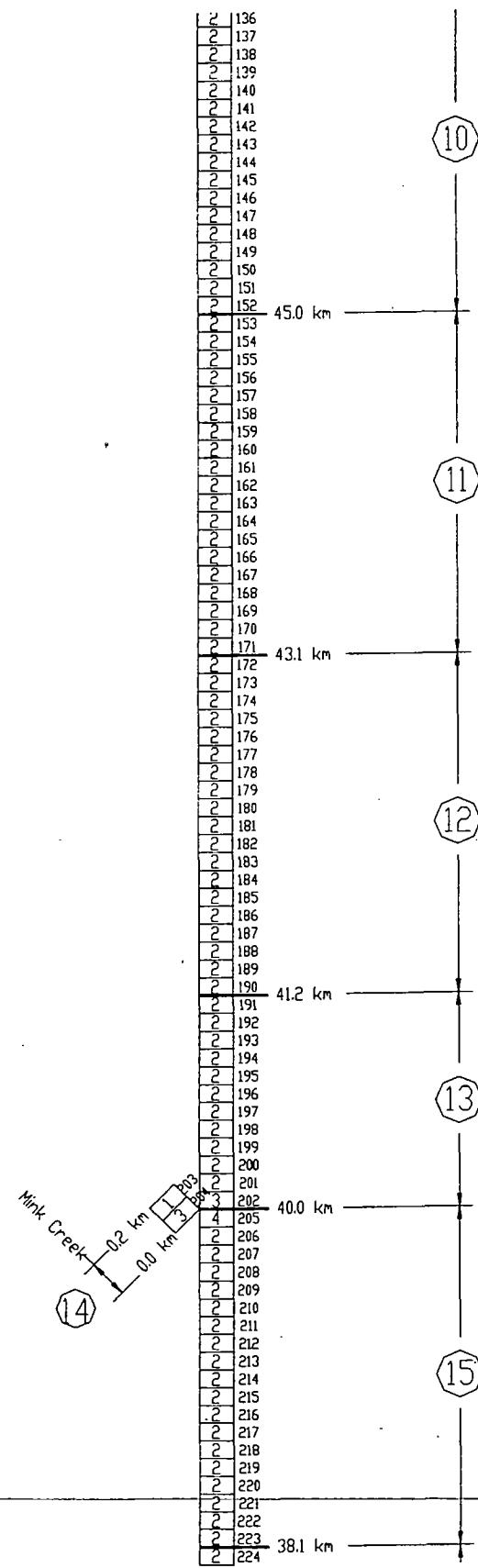


Appendix A Stream Network

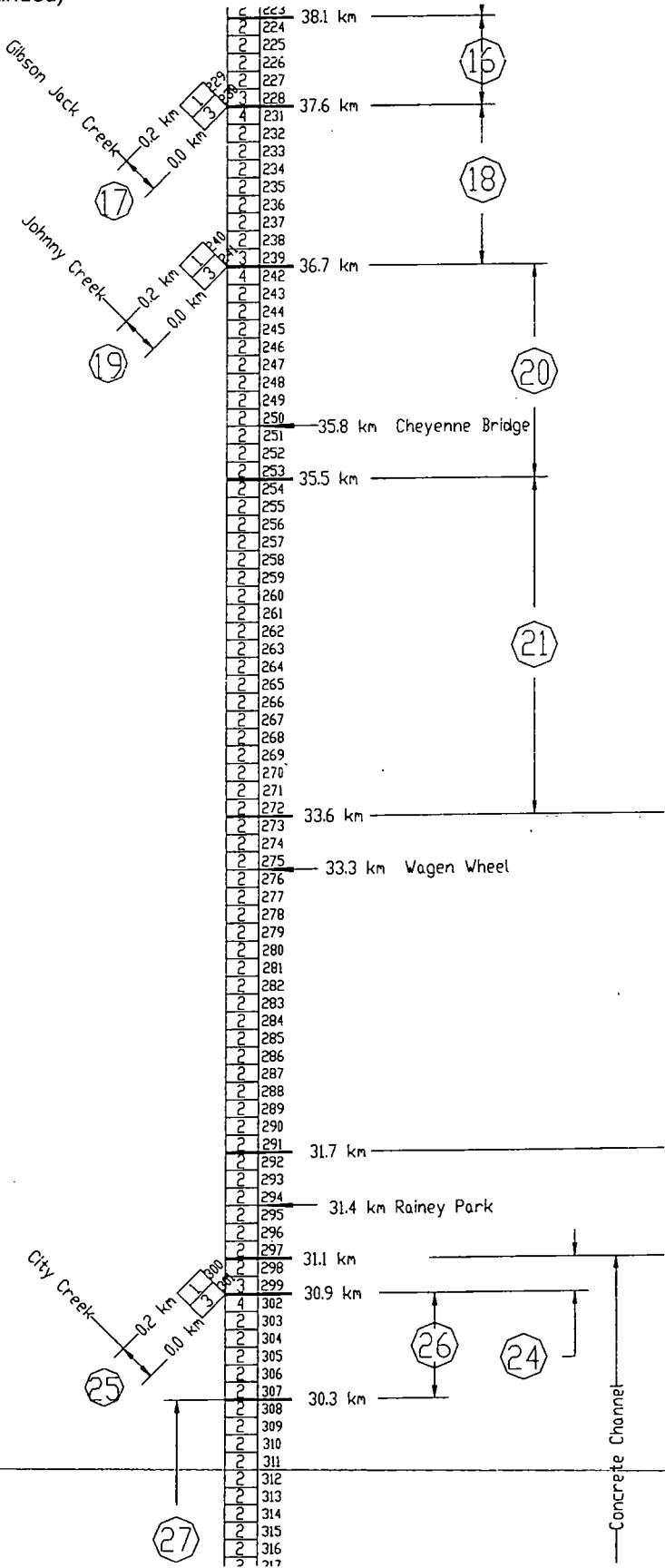
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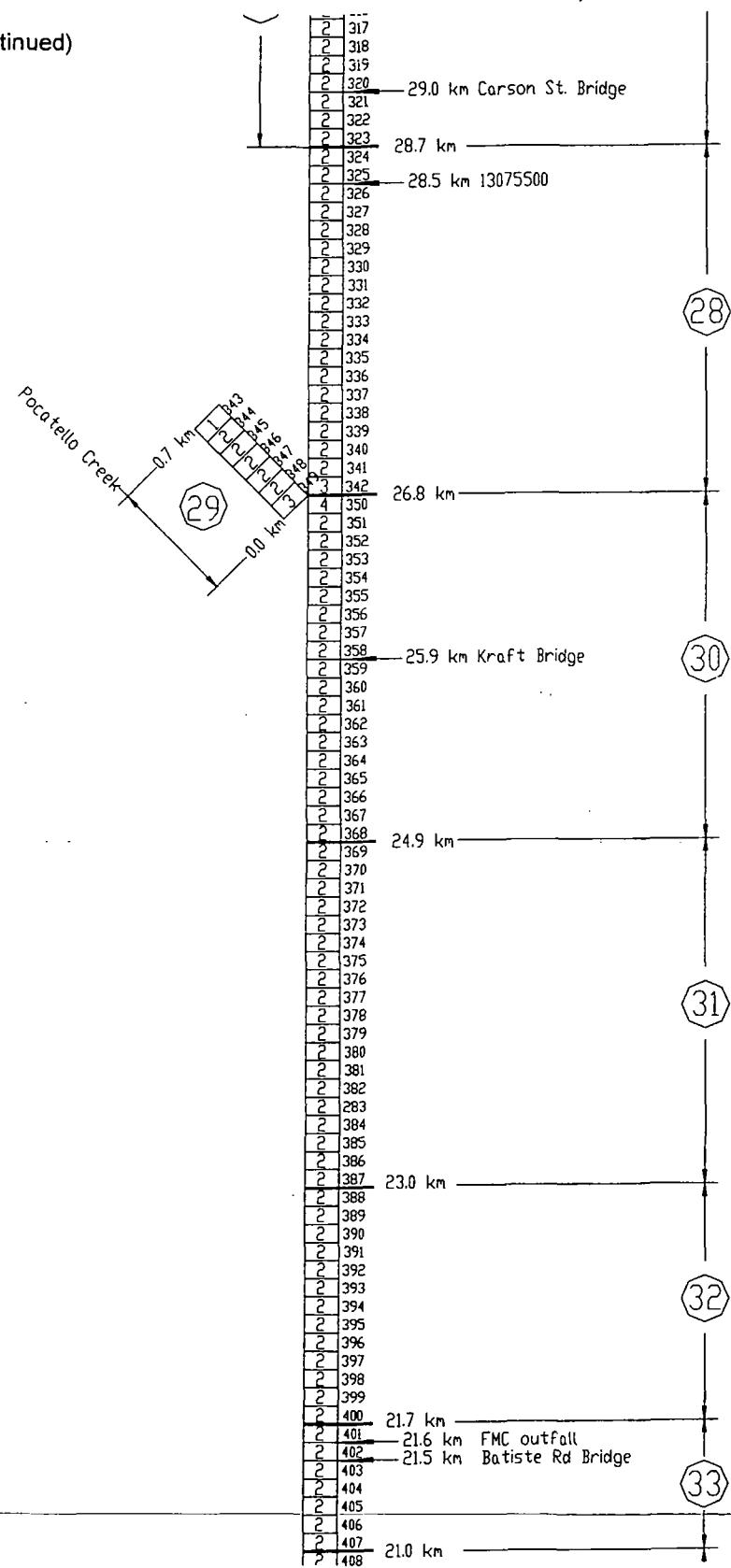
APPENDIX A (continued)



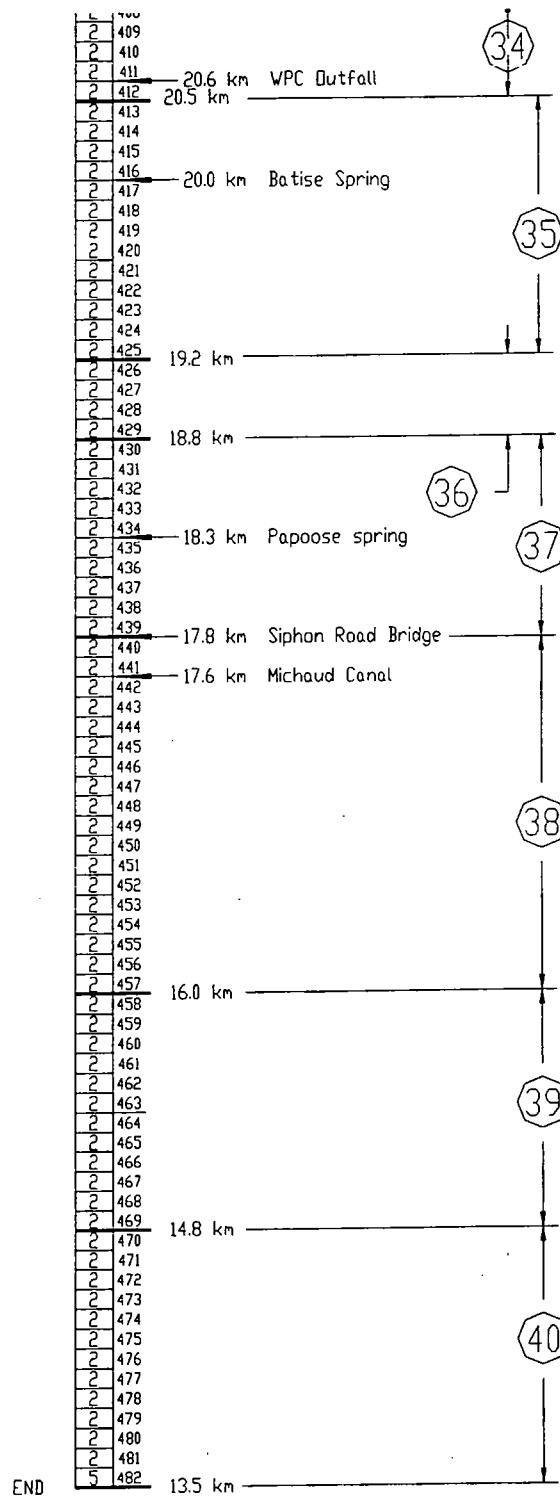
APPENDIX A (continued)



APPENDIX A (continued)



APPENDIX A (continued)



APPENDIX B Sampling Locations along the Portneuf River (Source: the Portneuf Database)

STREAM	SITE ID	SITE INFO	RIVER DISTANCE (km)
Portneuf River	CMP-1	Topaz gage USGS Station 13073000	78.7
Portneuf River	CMP-5	50 yds below I-15 at Inkom	53.8
Marsh Creek	MC-5	1/5 mi above Goodenough Creek nr Inkom	53.3
Jackson Creek	Station 4	road crossing	51.5
Rapid Creek	Station 5	USGS Station 13075100 nr Inkom	51.5
Portneuf River	CMP-6	Cement plant at Inkom	51.4
Portneuf River	Station 6	0.8km below Rapid Creek nr Inkom	50.7
Indian Creek	Station 6	county rd crossing	50.7
Portneuf River	CMP-7	Old Inkom HWY bridge at Blackrock	44.4
Portneuf River	Cheyenne Bridge	Cheyenne Rd Bridge at Pocatello	35.8
Portneuf River	CMP-8	Bannock HWY Bridge at Pocatello	33.3
Portneuf River	Rainey Park	Rainey Park at Pocatello	31.4
Portneuf River	CMP-9	head of concrete channel at Pocatello	31.1
Portneuf River	CMP-10	Carson St Bridge at Pocatello	29.0
Portneuf River	USGS Station 13075500	nr Carson St USGS Station 13075500 at Pocatello	28.5
Pocatello Creek	HWY 30	west side of HWY 30 intersection below culvert at Pocatello	26.8
Portneuf River	Station 2	Old State Bridge nr JR Simplot nr Pocatello	26.8
Pocatello Creek NF	USGS Station 13075600	at Parks Rd USGS Station 13075600 nr Pocatello	26.8
Pocatello Creek SF	USGS Station 13075700	USGS Station 13075700 nr Pocatello	26.8
Pocatello Creek SF	Station 8	USGS Station 13075700 nr Pocatello	26.8
Pocatello Creek NF	Station 9	at Parks Rd USGS Station 13075600 nr Pocatello	26.8
Portneuf River	Kraft Bridge	Kraft Rd Bridge at Pocatello	25.9
Portneuf River	CMP-11	HWY 30 Bridge above JR Simplot nr Pocatello	22.9
Portneuf River	Station 3	90m above Simplot discharge canal nr Pocatello	22.0
Portneuf River	Station 4	1.5m below Simplot discharge canal nr Pocatello	21.8
Portneuf River	T-1	Above FMC & Swanson Springs complex nr Pocatello	21.7
Portneuf River	Industry 2	FMC Outfall 12m south of I-86 nr Pocatello	21.6
Portneuf River	Batiste Bridge	Batiste Rd Bridge nr Pocatello	21.5
Portneuf River	T-2	Below FMC & Swanson Springs complex nr Pocatello	21.3
Portneuf River	T-3	500m below Batiste Rd Bridge above WPC outfall nr Pocatello	21.0
Portneuf River	Station 6	20m above WPC outfall nr Pocatello	20.7
WPC outfall	WPC outfall	City of Pocatello WPC outfall nr Pocatello	20.6

APPENDIX B (continued)

STREAM	SITE_ID	SITE_INFO	RIVER DISTANCE (km)
Portneuf River	T-4	Below WPC outfall nr Pocatello	20.5
Portneuf River	T-6	Above Batiste Springs Trout Farm discharge nr Pocatello	20.2
Batiste Spring	USGS Station 13075810	nr source USGS Station 13075810 nr Pocatello	20.0
Portneuf River	T-7	Below Batiste Springs Trout Farm discharge nr Pocatello	19.8
Portneuf River	T-8	Between Batiste and Papoose Springs nr Pocatello	19.2
Portneuf River	T-9	Above Papoose Springs nr Pocatello	18.8
Papoose Spring	Papoose Spring	Papoose Spring nr Pocatello	18.3
Portneuf River	T-10	Below Papoose Spring nr Pocatello	18.2
Siphon Rd Spring	USGS Station 13075890	at source USGS Station 13075890 nr Pocatello	17.9
Portneuf River	USGS Station 13075909	Siphon Rd Bridge USGS Station 13075909 nr Pocatello	17.8
Fort Hall Michaud Canal	USGS Station 13075900	Ft Hall Michaud Canal USGS Station 13075900 nr Pocatello	17.6
Portneuf River	USGS Station 13075910	nr Tyhee USGS Station 13075910 nr Pocatello	16.0
Portneuf River	nr Reservation Rd	nr Reservation Rd nr Pocatello	13.5

APPENDIX C Hydraulic Characteristics of Pocatello Creek and Marsh Creek

Table C-1. Hydraulic Characteristics of Pocatello Creek

Sample Date	Integrated Discharge (m ³ /sec)	Integrated Area (m ²)	Top Width (m)	D=A/W	V=Q/A Mean Velocity (m/sec)
11/03/99	0.089	1.17	3.7	0.271	0.089
11/30/99	0.09	1.28	4	0.298	0.075
04/04/00	0.093	0.85	2.5	0.27	0.137
05/03/00	0.361	1.55	4	0.366	0.246
10/10/00	0.179	1.29	2.25	0.383	0.208

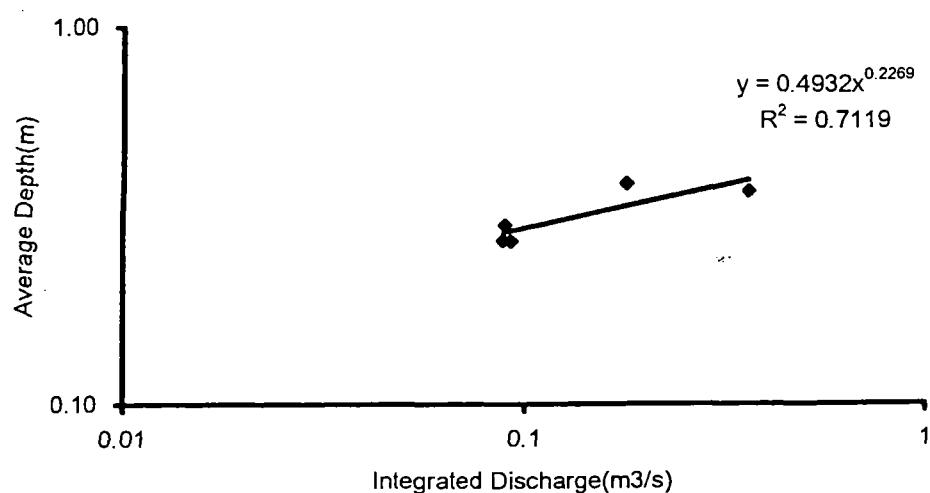
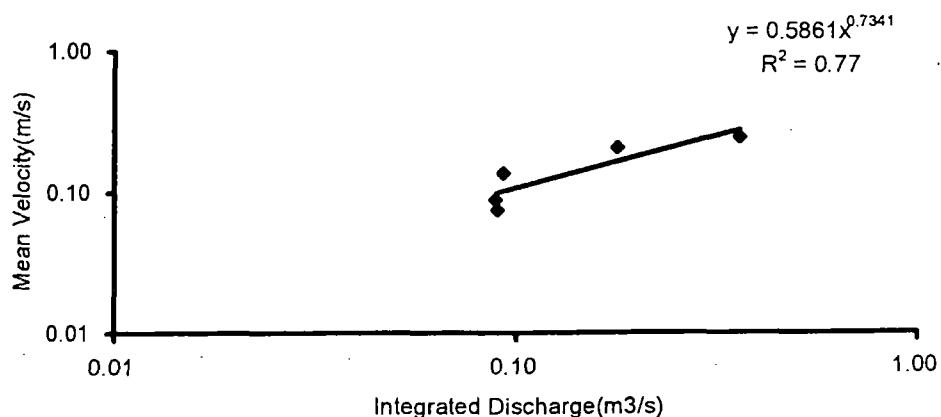


Fig.C-1. Hydraulic Characteristics' Curves of Pocatello Creek

Table C-2. Hydraulic Characteristics of Marsh Creek (USGS Station 13075000)

Sample Date	Top Width (m)	Channel Area (m ²)	Mean Velocity (m/s)	Gage Height (m)	Stream Flow (m ³ /s)	Avg Depth (m)
Date						
10/29/1973	0.41	3.93	0.68	1.01	2.64	3.87
12/03/1973	0.42	4.33	0.69	1.05	3.00	4.12
01/08/1974	0.53	3.23	0.71	0.91	2.30	3.56
02/12/1974	0.45	2.65	0.81	0.85	2.14	3.12
03/18/1974	0.66	7.79	0.59	1.14	4.58	6.83
04/30/1974	0.46	8.88	0.52	1.19	4.61	7.45
06/05/1974	0.56	3.03	0.70	0.88	2.12	3.43
07/09/1974	0.50	2.49	0.58	0.84	1.44	2.98
08/12/1974	0.54	3.40	0.53	0.95	1.81	3.56
09/24/1974	0.72	6.50	0.34	1.12	2.20	5.81
11/05/1974	0.50	3.72	0.76	1.02	2.83	3.64
12/17/1974	0.50	3.63	0.74	0.95	2.69	3.81
02/04/1975	0.42	3.73	0.71	0.94	2.65	3.95
03/17/1975	0.50	4.16	0.84	1.03	3.51	4.04
05/13/1975	0.48	8.71	0.51	1.17	4.41	7.43
06/22/1975	0.53	6.32	0.49	1.50	3.11	4.20
08/05/1975	0.53	8.15	0.26	1.20	2.11	6.80
09/16/1975	0.63	5.07	0.46	1.25	2.31	4.06
10/28/1975	0.49	8.18	0.38	1.28	3.11	6.40
12/11/1975	0.47	8.42	0.36	1.30	3.06	6.45
01/22/1976	0.55	5.81	0.36	1.02	2.08	5.69
03/08/1976	0.45	5.65	0.44	1.09	2.49	5.18
04/20/1976	0.47	8.56	0.56	1.36	4.81	6.31
06/01/1976	0.58	4.99	0.43	1.02	2.13	4.89
07/13/1976	0.60	5.02	0.23	0.91	1.17	5.50
09/08/1976	0.38	5.60	0.32	1.11	1.81	5.04
10/19/1976	0.59	2.53	0.87	1.12	2.19	2.26
11/30/1976	0.40	2.34	0.85	1.05	1.99	2.23
01/17/1977	0.45	5.23	0.34	0.97	1.81	5.38
03/07/1977	0.39	3.28	0.67	1.04	2.20	3.16
05/24/1977	0.45	5.56	0.38	1.01	2.10	5.52
07/05/1977	0.44	4.09	0.32	1.00	1.30	4.08
08/16/1977	0.67	2.96	0.35	1.00	1.04	2.96
09/28/1977	0.55	3.31	0.57	1.09	1.90	3.04
11/08/1977	0.64	3.30	0.61	1.02	2.00	3.24
12/19/1977	0.71	3.59	0.65	1.05	2.34	3.41
02/07/1978	0.46	3.92	0.74	1.16	2.91	3.38
03/15/1978	0.54	3.83	0.69	1.12	2.63	3.40
04/28/1978	0.45	6.79	0.53	1.25	3.59	5.42
05/30/1978	0.62	5.14	0.41	1.05	2.13	4.91
07/11/1978	0.57	5.02	0.21	1.00	1.07	5.02
08/24/1978	0.60	3.97	0.42	1.16	1.66	3.41
09/25/1978	0.61	4.97	0.36	1.27	1.79	3.92
11/07/1978	0.55	6.06	0.29	1.06	1.75	5.73
12/18/1978	0.51	5.54	0.28	0.98	1.55	5.64
01/22/1979	0.50	2.29	0.48	0.80	1.11	2.86
03/05/1979	0.57	3.62	0.64	1.02	2.31	3.54
04/18/1979	0.59	4.61	0.63	1.15	2.89	4.00
05/22/1979	0.58	2.83	0.43	0.89	1.21	3.19
07/10/1979	0.75	3.96	0.26	1.15	1.02	3.45
08/22/1979	0.49	4.91	0.30	1.33	1.49	3.71
10/24/1979	0.77	3.83	0.48	1.16	1.84	3.30
12/11/1979	0.52	2.95	0.54	0.98	1.58	3.02
02/05/1980	0.54	3.41	0.70	1.05	2.39	3.24
03/24/1980	0.60	3.91	0.66	1.05	2.56	3.74
05/16/1980	0.41	5.13	0.96	1.30	4.92	3.94
07/13/1980	0.68	2.90	0.53	0.98	1.57	2.94
07/17/1980	0.58	4.57	0.22	0.98	1.00	4.69
09/12/1980	0.52	5.92	0.72	1.12	2.47	5.29
10/22/1980	0.37	2.72	0.84	0.97	2.30	2.82

Table C-2 (continued)

Sample Date	Top Width (m)	Channel Area (m ²)	Mean Velocity (m/s)	Gage Height (m)	Stream Flow (m ³ /s)	Avg Depth (m)
Date						
11/06/1980	0.52	4.76	0.47	0.94	2.24	5.08
12/11/1980	0.56	2.18	0.92	0.88	2.00	2.48
01/09/1981	0.51	2.66	0.81	0.94	2.16	2.83
02/05/1981	0.58	2.47	0.96	0.91	2.39	2.71
02/25/1981	0.37	4.95	0.66	1.05	3.28	4.74
04/14/1981	0.40	3.18	0.53	0.84	1.68	3.78
05/07/1981	0.36	1.64	0.80	0.79	1.31	2.09
05/18/1981	0.35	4.26	0.41	0.87	1.73	4.87
06/18/1981	0.61	2.53	0.78	0.92	1.97	2.75
07/06/1981	0.38	1.66	0.60	0.77	1.00	2.15
08/18/1981	0.46	2.16	0.56	0.84	1.20	2.56
09/21/1981	0.36	3.27	0.55	0.96	1.78	3.42
11/03/1981	0.34	3.59	0.56	0.99	2.00	3.62
12/28/1981	0.37	3.59	0.62	1.00	2.24	3.60
02/09/1982	0.37	3.99	0.46	0.94	1.83	4.27
03/22/1982	0.32	5.96	0.61	1.18	3.65	5.07
05/04/1982	0.35	9.21	0.72	1.68	6.65	5.47
06/14/1982	0.47	6.62	0.55	1.17	3.65	5.64
07/26/1982	0.34	3.51	0.67	1.02	2.36	3.44
09/07/1982	0.34	3.86	0.66	1.07	2.53	3.62
10/26/1982	0.35	6.76	0.51	1.22	3.45	5.55
12/06/1982	0.37	5.65	0.67	1.11	3.76	5.11
01/12/1983	0.38	5.67	0.62	1.10	3.54	5.14
03/01/1983	0.43	10.87	0.62	1.45	6.74	7.49
04/20/1983	0.50	6.26	0.67	1.14	4.19	5.48
05/24/1983	0.42	10.31	0.79	1.53	8.15	6.75
06/07/1983	0.50	12.36	0.64	1.62	7.92	7.62
07/06/1983	0.44	5.81	0.58	1.12	3.40	5.20
08/15/1983	0.62	5.90	0.53	1.08	3.14	5.47
09/19/1983	0.43	5.87	0.53	1.09	3.11	5.38
11/08/1983	0.45	8.35	0.55	1.28	4.64	6.52
01/04/1984	0.47	6.30	0.55	1.14	3.48	5.53
02/23/1984	0.47	5.96	0.54	1.10	3.23	5.41
04/09/1984	0.47	8.86	0.57	1.36	5.07	6.52
05/04/1984	0.58	10.31	0.71	1.62	7.53	6.38
05/31/1984	0.44	11.33	0.79	1.79	9.00	6.35
07/17/1984	0.42	5.30	0.52	1.03	2.72	5.16
08/28/1984	0.49	6.35	0.58	1.13	3.68	5.60
10/09/1984	0.34	5.74	0.72	1.18	4.13	4.88
11/13/1984	0.47	8.96	0.45	1.21	4.02	7.38
01/02/1985	0.74	6.82	0.46	1.08	3.11	6.32
02/06/1985	0.53	6.14	0.48	1.05	2.94	5.86
03/18/1985	0.66	7.60	0.47	1.16	3.57	6.58
05/01/1985	0.63	9.57	0.40	1.24	3.88	7.69
06/03/1985	0.70	8.02	0.34	1.08	2.69	7.41
07/10/1985	0.50	5.32	0.30	0.88	1.62	6.04
09/22/1986	0.60	8.02	0.46	1.07	3.68	7.49
11/05/1986	0.65	8.77	0.43	1.05	3.76	8.34
12/08/1986	0.65	7.92	0.43	1.06	3.42	7.47
01/26/1987	0.58	7.10	0.43	1.00	3.03	7.10
03/09/1987	0.65	10.50	0.51	1.25	5.32	8.40
04/13/1987	0.66	6.52	0.41	0.94	2.64	6.95
05/26/1987	0.68	7.00	0.43	1.02	3.03	6.85
07/08/1987	0.47	4.42	0.35	0.80	1.55	5.52
08/17/1987	0.62	5.61	0.39	0.82	2.19	6.82
09/24/1987	0.65	4.90	0.45	0.91	2.23	5.39
09/28/1987	0.60	5.09	0.49	0.92	2.49	5.51
11/09/1987	0.48	5.87	0.90	0.96	2.69	6.10
12/21/1987	0.57	5.29	0.47	0.92	2.49	5.76
01/25/1988	0.62	5.52	0.42	0.96	2.81	5.75
03/07/1988	0.65	6.09	0.52	1.01	3.17	6.02
04/18/1988	0.74	4.22	0.45	0.85	1.88	4.98

Table C-2 (continued)

Sample Date Date	Top Width (m)	Channel Area (m ²)	Mean Velocity (m/s)	Gage Height (m)	Stream Flow (m ³ /s)	Avg Depth (m)
05/31/1988	0.61	5.27	0.41	0.87	2.13	6.02
07/07/1988	0.60	1.93	0.57	0.72	1.10	2.70
08/19/1988	0.57	2.17	0.55	0.75	1.21	2.91
10/24/1988	0.56	2.35	0.76	0.84	1.78	2.79
11/21/1988	0.54	2.98	0.61	0.86	1.81	3.47
01/04/1989	0.53	2.57	0.55	0.80	1.40	3.23
02/09/1989	0.72	2.53	0.62	0.79	1.56	3.19
03/20/1989	0.58	6.93	0.51	1.06	3.54	6.53
05/03/1989	0.42	3.79	0.53	0.84	2.01	4.49
05/03/1989	0.50	5.63	0.34	0.84	1.90	6.67
06/12/1989	0.84	5.64	0.30	0.84	1.68	6.68
06/13/1989	0.38	4.05	0.45	0.84	1.80	4.80
06/13/1989	0.47	2.87	0.66	0.84	1.89	3.40
07/26/1989	0.43	2.39	0.61	0.79	1.46	3.01
09/15/1989	0.56	2.96	0.66	0.87	1.95	3.42
10/23/1989	0.76	3.42	0.68	0.90	2.31	3.79
01/03/1990	0.42	2.77	0.63	0.83	1.75	3.34
02/23/1990	0.66	3.36	0.66	0.88	2.22	3.83
04/05/1990	0.56	2.76	0.62	0.82	1.71	3.35
05/23/1990	0.43	3.05	0.62	0.87	1.88	3.51
06/27/1990	0.56	2.42	0.55	0.82	1.32	2.96
06/27/1990	0.62	2.40	0.54	0.82	1.29	2.92
08/24/1990	0.52	2.79	0.48	0.85	1.33	3.27
10/03/1990	0.65	2.94	0.62	0.88	1.80	3.34
11/14/1990	0.73	2.51	0.73	0.85	1.82	2.96
01/15/1991	0.52	3.08	0.59	0.82	1.83	3.76
03/14/1991	0.48	3.21	0.65	0.87	2.10	3.71
04/25/1991	0.43	3.47	0.70	0.91	2.41	3.79
05/17/1991	0.54	3.73	0.69	0.94	2.57	3.98
06/19/1991	0.44	2.88	0.55	0.86	1.60	3.35
07/08/1991	0.62	2.90	0.45	0.87	1.32	3.33
09/17/1991	0.67	3.96	0.47	1.00	1.87	3.95
10/29/1991	0.45	3.15	0.59	0.90	1.86	3.49
12/04/1991	0.52	2.25	0.76	0.80	1.70	2.79
01/14/1992	0.56	2.41	0.72	0.80	1.73	2.99
03/05/1992	0.61	2.99	0.65	0.86	1.94	3.48
04/15/1992	0.66	2.07	0.54	0.74	1.12	2.80
05/28/1992	0.48	2.66	0.47	0.86	1.25	3.10
07/08/1992	0.67	2.94	0.29	0.87	0.85	3.36
08/13/1992	0.56	2.03	0.32	0.84	0.65	2.44
09/15/1992	0.51	2.73	0.46	0.92	1.27	2.98
09/15/1992	0.56	2.42	0.53	0.87	1.29	2.77
10/21/1992	0.56	1.78	0.68	0.76	1.21	2.34
11/19/1992	0.39	3.60	0.35	0.77	1.28	4.71
01/14/1993	0.39	3.62	0.43	0.76	1.56	4.77
03/17/1993	0.45	8.34	0.50	1.15	4.19	7.26
03/24/1993	0.41	8.08	0.53	1.17	4.30	6.91
04/13/1993	0.44	5.56	0.48	0.94	2.65	5.89
05/24/1993	0.51	7.30	0.52	1.10	3.76	6.62
06/23/1993	0.48	4.34	0.40	0.89	1.73	4.87
07/20/1993	0.40	3.25	0.37	0.86	1.19	3.80
09/23/1993	0.44	6.44	0.25	1.19	1.63	5.42
10/25/1993	0.50	5.78	0.33	1.03	1.91	5.61
11/11/1993	0.45	5.02	0.37	0.93	1.87	5.38
01/06/1994	0.41	2.42	0.87	0.87	2.09	2.76
02/10/1994	0.50	3.91	0.43	0.85	1.68	4.60
03/29/1994	0.41	4.08	0.40	0.82	1.62	4.97
05/19/1994	0.41	3.43	0.36	0.88	1.23	3.91
06/21/1994	0.39	5.31	0.20	1.09	1.06	4.90
07/26/1994	0.41	2.35	0.28	0.91	0.65	2.58
09/01/1994	0.41	2.64	0.44	0.97	1.15	2.72
10/19/1994	0.42	4.16	0.33	0.88	1.38	4.71

Table C-2 (continued)

Sample Date	Top Width (m)	Channel Area (m ²)	Mean Velocity (m/s)	Gage Height (m)	Stream Flow (m ³ /s)	Avg Depth (m)
Date						
11/23/1994	0.39	1.36	0.73	0.71	0.98	1.92
01/12/1995	0.54	6.44	0.45	0.97	2.86	6.64
03/23/1995	0.35	6.70	0.49	1.05	3.25	6.37
04/19/1995	0.38	4.83	0.41	0.86	1.96	5.60
05/17/1995	0.34	5.65	0.46	0.96	2.60	5.88
06/13/1995	0.32	7.05	0.41	1.18	2.89	5.96
07/13/1995	0.41	4.33	0.27	1.13	1.19	3.84
08/16/1995	0.39	3.35	0.33	1.06	1.11	3.16
09/20/1995	0.39	3.45	0.54	1.07	1.86	3.21
10/25/1995	0.43	5.08	0.34	0.93	1.73	5.47
12/05/1995	0.37	4.89	0.43	0.91	2.11	5.38
01/31/1996	0.41	2.51	0.61	0.90	1.53	2.78
03/19/1996	0.51	6.39	0.48	1.05	3.06	6.06
05/23/1996	0.37	8.99	0.50	1.26	4.53	7.13
06/18/1996	0.56	6.44	0.31	0.97	2.00	6.64
08/20/1996	0.58	3.09	0.41	1.01	1.28	3.06
10/24/1996	0.50	2.76	0.70	0.98	1.93	2.82
12/18/1996	0.59	3.90	0.64	0.95	2.48	4.10
01/28/1997	0.42	5.31	0.70	1.12	3.74	4.75
03/05/1997	0.47	3.58	0.63	0.90	2.27	3.96
04/15/1997	0.60	4.70	0.68	1.04	3.20	4.52
05/29/1997	0.48	4.89	0.86	1.16	4.19	4.20
07/08/1997	0.59	3.53	0.52	0.98	1.85	3.61
08/13/1997	0.43	4.78	0.47	1.17	2.38	4.09
09/16/1997	0.68	4.57	0.47	1.08	2.16	4.22
11/06/1997	0.63	3.53	0.65	0.96	2.29	3.68
12/18/1997	0.52	2.98	0.70	0.90	2.08	3.32
02/12/1998	0.48	5.22	0.65	1.04	3.40	5.04
03/17/1998	0.48	4.12	0.74	1.05	3.03	3.93
04/24/1998	0.33	5.06	0.77	1.16	3.88	4.35
05/22/1998	0.39	10.31	0.48	1.41	4.98	7.32
05/22/1998	0.46	10.22	0.50	1.41	5.15	7.27
07/22/1998	0.35	4.30	0.32	0.85	1.36	5.04
09/24/1998	0.59	3.76	0.50	1.00	1.87	3.78
10/22/1998	0.46	5.35	0.37	1.04	1.98	5.13
12/04/1998	0.41	5.36	0.43	0.99	2.29	5.43
01/21/1999	0.43	5.66	0.52	1.05	2.97	5.41
03/04/1999	0.41	4.95	0.54	0.99	2.69	4.98
04/20/1999	0.42	5.56	0.52	1.03	2.91	5.39
05/27/1999	0.40	5.31	0.52	1.05	2.74	5.04
07/08/1999	0.38	3.59	0.38	0.90	1.37	3.97
08/19/1999	0.40	3.99	0.38	0.98	1.53	4.10
10/21/1999	0.43	3.98	0.45	0.93	1.79	4.28
12/02/1999	0.55	3.05	0.59	0.88	1.81	3.46
01/20/2000	0.43	4.85	0.58	1.03	2.80	4.69
03/07/2000	0.51	4.04	0.57	0.95	2.29	4.25
04/24/2000	0.55	5.12	0.45	0.96	2.32	5.35
06/13/2000	0.55	3.25	0.36	0.92	1.16	3.53
08/24/2000	0.61	3.98	0.25	1.08	0.98	3.69
10/19/2000	0.58	4.06	0.44	1.04	1.79	3.89
12/06/2000	0.50	5.22	0.30	0.89	1.56	5.89
01/17/2001	0.49	1.83	0.72	0.79	1.31	2.32
02/27/2001	0.55	2.57	0.82	0.93	2.10	2.78
04/19/2001	0.47	2.41	0.77	0.87	1.84	2.76
05/21/2001	0.59	2.27	0.39	0.87	0.89	2.62
07/09/2001	0.55	4.74	0.23	1.26	1.06	3.75
08/15/2001	0.56	3.47	0.27	1.06	0.93	3.27
10/03/2001	0.54	2.63	0.51	0.92	1.33	2.87
11/16/2001	0.36	2.15	0.63	0.86	1.35	2.51

Note: *Source: http://water.usgs.gov/nwis/help?streamflow_measurements_data

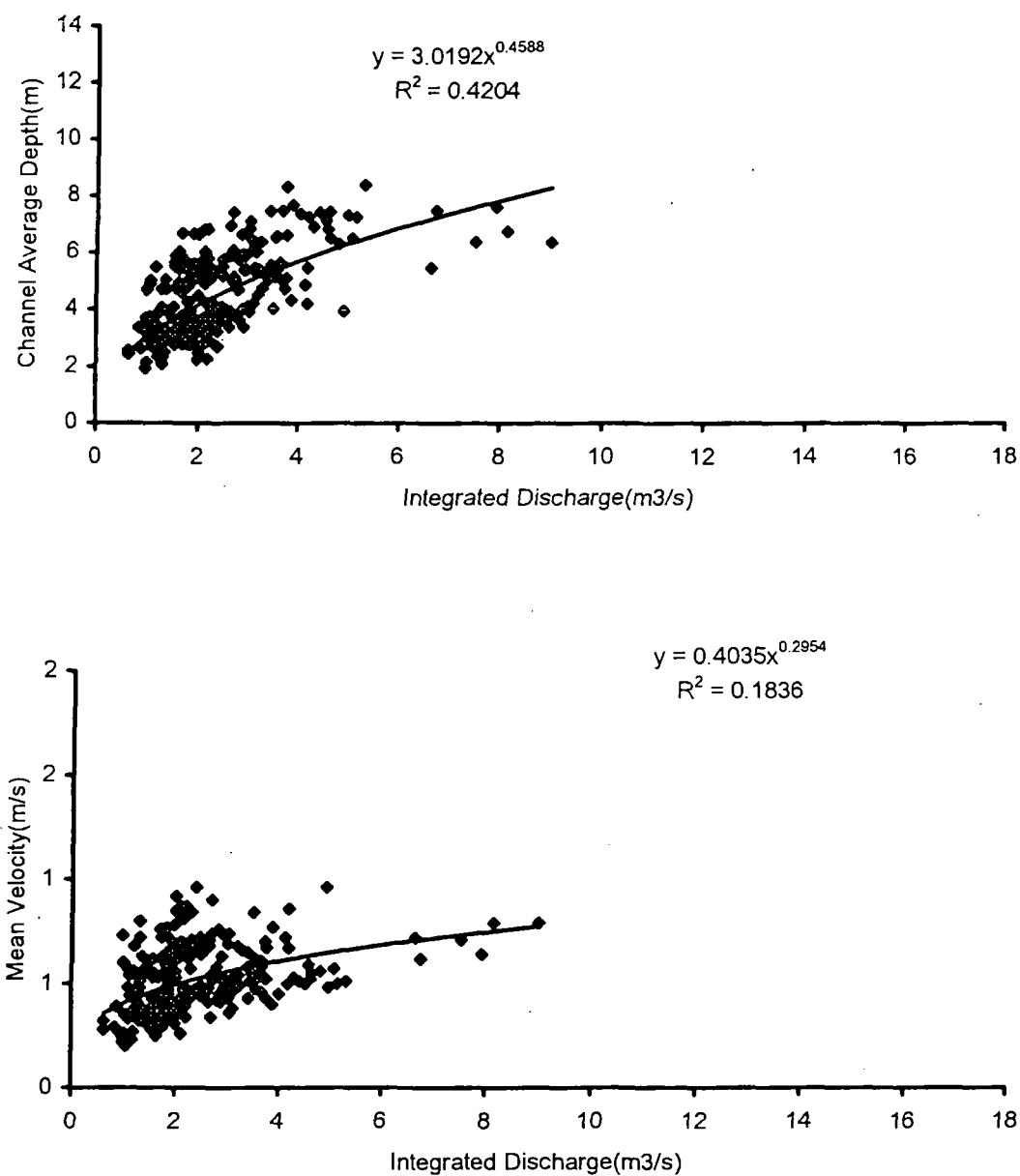


Fig.C-2. Hydraulic Characteristics' Curves of Marsh Creek (USGS 13075000)

**APPENDIX D Field Data Used to Calculate the Relationship of
NO₂₃_N and NO₃_N, TOT_P and OPHOS_P**

Stream	Sample-date	NO ₂₃ N (mg/L)	NO ₃ N (mg/L)
Portneuf/Marsh Valley Canal	9/19/1980	1.3	1.3
Portneuf/Marsh Valley Canal	7/14/1980	0.49	0.49
Portneuf/Marsh Valley Canal	6/25/1980	0.47	0.46
Portneuf/Marsh Valley Canal	6/19/1981	0.45	0.44
Portneuf/Marsh Valley Canal	6/4/1980	0.43	0.42
Portneuf/Marsh Valley Canal	7/12/1981	0.4	0.37
Portneuf/Marsh Valley Canal	4/15/1981	0.38	0.35
Portneuf/Marsh Valley Canal	9/29/1981	0.38	0.35
Portneuf/Marsh Valley Canal	5/7/1991	0.37	0.36
Portneuf/Marsh Valley Canal	8/18/1981	0.32	0.29
Portneuf/Marsh Valley Canal	8/12/1980	0.24	0.23
Marsh Creek	9/18/1980	2.4	2.4
Marsh Creek	9/18/1980	2.1	2.1
Marsh Creek	10/30/1979	1.8	1.8
Marsh Creek	8/11/1980	1.8	1.8
Marsh Creek	12/11/1980	1.7	1.7
Marsh Creek	12/11/1980	1.5	1.5
Marsh Creek	2/13/1980	1.5	1.5
Marsh Creek	12/11/1980	1.5	1.5
Marsh Creek	12/11/1980	1.4	1.4
Marsh Creek	2/14/1980	1.4	1.4
Marsh Creek	2/5/1981	1.3	1.3
Marsh Creek	2/5/1981	1.3	1.3
Marsh Creek	12/17/1979	1.3	1.3
Marsh Creek	10/21/1990	1.3	1.3
Marsh Creek	4/13/1981	1.2	1.2
Marsh Creek	2/14/1980	1.2	1.2
Marsh Creek	4/13/1981	1.1	1.1
Marsh Creek	12/18/1979	1.1	1.1
Marsh Creek	10/22/1980	1.1	1.1
Marsh Creek	2/5/1981	1.1	1.1
Marsh Creek	2/13/1980	1.1	1.1
Marsh Creek	7/12/1980	1.1	1.1
Marsh Creek	5/6/1981	1	0.99
Marsh Creek	9/18/1980	1	0.98
Marsh Creek	4/16/1980	1	0.96
Marsh Creek	4/16/1980	0.97	0.97
Marsh Creek	6/18/1981	0.95	0.94
Marsh Creek	10/31/1979	0.92	0.82
Marsh Creek	10/22/1980	0.86	0.85
Marsh Creek	9/18/1980	0.85	0.82
Marsh Creek	2/5/1981	0.85	0.81
Marsh Creek	7/11/1981	0.82	0.8
Marsh Creek	7/11/1981	0.8	0.79
Marsh Creek	9/19/1980	0.78	0.77
Marsh Creek	2/13/1980	0.78	0.76
Marsh Creek	6/24/1980	0.77	0.76
Marsh Creek	7/14/1980	0.73	0.72
Marsh Creek	6/3/1980	0.72	0.71
Marsh Creek	12/11/1980	0.72	0.71
Marsh Creek	4/15/1981	0.7	0.68
Marsh Creek	2/5/1981	0.69	0.67
Marsh Creek	9/29/1981	0.69	0.66
Marsh Creek	4/16/1980	0.68	0.67
Marsh Creek	4/17/1980	0.68	0.63
Marsh Creek	7/12/1980	0.66	0.64

APPENDIX D (continued)

Stream	Sample-date	NO23_N (mg/L)	NO3_N (mg/L)
Marsh Creek	2/21/1980	0.65	0.6
Marsh Creek	6/18/1981	0.65	0.56
Marsh Creek	9/28/1981	0.61	0.59
Marsh Creek	4/17/1980	0.6	0.57
Marsh Creek	5/7/1981	0.54	0.52
Marsh Creek	7/11/1981	0.54	0.5
Marsh Creek	12/17/1979	0.53	0.5
Marsh Creek	9/29/1981	0.52	0.49
Marsh Creek	4/13/1981	0.48	0.46
Marsh Creek	7/12/1981	0.45	0.43
Marsh Creek	7/11/1981	0.45	0.4
Marsh Creek	2/21/1980	0.43	0.4
Marsh Creek	4/15/1981	0.43	0.4
Marsh Creek	7/12/1980	0.41	0.41
Marsh Creek	5/7/1981	0.41	0.39
Marsh Creek	12/17/1979	0.4	0.37
Marsh Creek	6/18/1981	0.39	0.38
Marsh Creek	7/13/1980	0.39	0.38
Marsh Creek	6/24/1980	0.38	0.36
Marsh Creek	8/12/1980	0.38	0.36
Marsh Creek	8/18/1981	0.38	0.35
Marsh Creek	7/13/1980	0.37	0.37
Marsh Creek	6/25/1980	0.36	0.34
Marsh Creek	10/31/1979	0.36	0.34
Marsh Creek	7/14/1980	0.35	0.35
Marsh Creek	8/17/1981	0.32	0.29
Marsh Creek	6/18/1981	0.32	0.26
Marsh Creek	6/2/1980	0.31	0.29
Marsh Creek	8/18/1981	0.31	0.28
Marsh Creek	4/13/1981	0.31	0.28
Marsh Creek	6/2/1980	0.3	0.29
Marsh Creek	7/12/1980	0.29	0.28
Marsh Creek	6/19/1981	0.28	0.26
Marsh Creek	8/17/1981	0.26	0.22
Marsh Creek	10/21/1980	0.25	0.24
Marsh Creek	7/11/1981	0.25	0.23
Marsh Creek	7/11/1981	0.24	0.2
Marsh Creek	7/11/1981	0.23	0.21
Marsh Creek	4/14/1981	0.21	0.19
Marsh Creek	6/3/1980	0.2	0.18
Marsh Creek	7/12/1981	0.19	0.17
Marsh Creek	5/6/1981	0.18	0.16
Marsh Creek	7/13/1980	0.14	0.14
Marsh Creek	6/24/1980	0.13	0.12
Marsh Creek	4/17/1980	0.13	0.09
Marsh Creek	8/17/1981	0.11	0.08
Marsh Creek	8/12/1980	0.09	0.07
Marsh Creek	6/24/1980	0.08	0.07
Marsh Creek	10/30/1979	0.08	0.06
Marsh Creek	8/11/1980	0.07	0.06
Bell Marsh Creek	7/12/1981	0.06	0.05
Bell Marsh Creek	4/19/1980	0.05	0.05
Marsh Creek	5/6/1981	0.04	0.03
Marsh Creek	6/3/1980	0.02	0.01

APPENDIX D (continued)

Stream	Sample date	TOT P (mg/L)	OPHOS P (mg/L)
Bell Marsh Creek	7/12/1981	0.05	0.03
Bell Marsh Creek	4/19/1980	0.13	0.01
Dempsey Creek	2/22/1986	0.1	0.006
Dempsey Creek	3/23/1986	0.1	0.039
Dempsey Creek	6/17/1986	0.1	0.01
Dempsey Creek	7/8/1986	0.1	0.019
Dempsey Creek	4/11/1986	0.2	0.015
Dempsey Creek	4/22/1986	0.2	0.02
Dempsey Creek	5/6/1986	0.2	0.03
Dempsey Creek	6/3/1986	0.2	0.01
Dempsey Creek	3/10/1986	0.3	0.034
Dempsey Creek	5/20/1986	0.3	0.024
Indian Creek	11/18/1985	0.08	0.059
Indian Creek	3/23/1986	0.1	0.06
Indian Creek	5/20/1986	0.1	0.03
Indian Creek	6/3/1986	0.1	0.033
Indian Creek	6/17/1986	0.1	0.034
Indian Creek	7/8/1986	0.1	0.044
Indian Creek	4/11/1986	0.2	0.03
Indian Creek	4/22/1986	0.2	0.035
Indian Creek	5/6/1986	0.2	0.036
Indian Creek	2/22/1986	0.9	0.093
Indian Creek	3/10/1986	1.1	0.095
Jackson Creek	6/3/1986	0.1	0.018
Jackson Creek	6/17/1986	0.1	0.045
Jackson Creek	3/10/1986	0.2	0.047
Jackson Creek	3/23/1986	0.2	0.061
Jackson Creek	4/11/1986	0.2	0.028
Jackson Creek	5/6/1986	0.2	0.032
Jackson Creek	7/8/1986	0.2	0.107
Jackson Creek	2/22/1986	0.3	0.071
Jackson Creek	4/22/1986	0.3	0.032
Jackson Creek	5/20/1986	0.3	0.034
Jenkins Canyon	2/22/1986	0.9	0.402
Marsh Creek	8/17/1981	0.02	0.02
Marsh Creek	12/17/1979	0.03	0
Marsh Creek	12/11/1980	0.04	0.01
Marsh Creek	12/11/1980	0.04	0.03
Marsh Creek	4/13/1981	0.04	0.01
Marsh Creek	6/18/1981	0.04	0.02
Marsh Creek	6/18/1981	0.04	0.03
Marsh Creek	2/13/1980	0.05	0.03
Marsh Creek	12/11/1980	0.05	0.04
Marsh Creek	10/21/1990	0.05	0.04
Marsh Creek	7/8/1991	0.05	0.03
Marsh Creek	9/17/1991	0.05	0.03
Marsh Creek	6/24/1980	0.06	0.04
Marsh Creek	12/11/1980	0.06	0.04
Marsh Creek	8/18/1981	0.06	0.05
Marsh Creek	1/15/1991	0.06	0.06
Marsh Creek	3/14/1991	0.06	0.04
Marsh Creek	10/30/1979	0.07	0
Marsh Creek	10/31/1979	0.07	0.01
Marsh Creek	12/17/1979	0.07	0.01
Marsh Creek	12/17/1979	0.07	0
Marsh Creek	6/24/1980	0.07	0.05
Marsh Creek	8/12/1980	0.07	0.01
Marsh Creek	5/6/1981	0.07	0.02
Marsh Creek	9/18/1980	0.08	0.02
Marsh Creek	10/21/1980	0.08	0.01

APPENDIX D (continued)

Stream	Sample_date	TOT_P (mg/L)	OPHOS_P (mg/L)
Marsh Creek	2/5/1981	0.08	0.07
Marsh Creek	7/11/1981	0.08	0.08
Marsh Creek	5/17/1991	0.08	0.02
Marsh Creek	7/12/1980	0.09	0.05
Marsh Creek	7/13/1980	0.09	0.01
Marsh Creek	8/11/1980	0.09	0.03
Marsh Creek	9/18/1980	0.09	0
Marsh Creek	6/18/1981	0.09	0.03
Marsh Creek	6/18/1981	0.09	0.03
Marsh Creek	7/12/1981	0.09	0.09
Marsh Creek	2/14/1980	0.1	0.05
Marsh Creek	7/12/1980	0.1	0.01
Marsh Creek	8/11/1980	0.1	0.03
Marsh Creek	10/22/1980	0.1	0.05
Marsh Creek	7/11/1981	0.1	0.08
Marsh Creek	10/30/1979	0.11	0
Marsh Creek	2/13/1980	0.11	0.04
Marsh Creek	2/13/1980	0.11	0.05
Marsh Creek	7/13/1980	0.11	0.03
Marsh Creek	7/14/1980	0.11	0.01
Marsh Creek	2/5/1981	0.11	0.08
Marsh Creek	5/7/1981	0.11	0.04
Marsh Creek	9/18/1980	0.12	0.03
Marsh Creek	9/18/1980	0.12	0.02
Marsh Creek	4/13/1981	0.12	0.03
Marsh Creek	4/14/1981	0.12	0.03
Marsh Creek	11/14/1990	0.13	0.08
Marsh Creek	6/3/1980	0.14	0.04
Marsh Creek	4/15/1981	0.14	0.04
Marsh Creek	5/6/1981	0.15	0.04
Marsh Creek	6/24/1980	0.16	0.05
Marsh Creek	2/5/1981	0.16	0.08
Marsh Creek	7/13/1980	0.17	0.05
Marsh Creek	9/29/1981	0.17	0.04
Marsh Creek	4/16/1980	0.18	0.04
Marsh Creek	8/11/1980	0.18	0.09
Marsh Creek	9/28/1981	0.18	0.03
Marsh Creek	11/19/1992	0.18	0.04
Marsh Creek	7/11/1981	0.19	0.15
Marsh Creek	8/17/1981	0.19	0.06
Marsh Creek	4/17/1980	0.21	0.04
Marsh Creek	6/3/1980	0.21	0.02
Marsh Creek	5/6/1981	0.21	0.06
Marsh Creek	4/16/1980	0.22	0.04
Marsh Creek	6/24/1980	0.24	0.03
Marsh Creek	8/17/1981	0.25	0.14
Marsh Creek	4/13/1981	0.27	0.06
Marsh Creek	2/21/1980	0.31	0.19
Marsh Creek	4/17/1980	0.63	0.14
Marsh Creek	2/21/1980	0.85	0.25
Marsh Creek	6/3/1980	1.4	0.07
Marsh Creek	4/16/1980	1.5	0.13
Marsh Creek	6/2/1980	1.8	0.05
Pocatello Creek	7/14/1999	0.12	0.08
Pocatello Creek	4/15/1999	0.53	0.2
Pocatello Creek	4/15/1999	0.55	0.19
Pocatello Creek NF	11/18/1985	0.07	0.048
Pocatello Creek NF	3/23/1986	0.2	0.041
Pocatello Creek NF	6/17/1986	0.2	0.065
Pocatello Creek NF	7/8/1986	0.2	0.079

APPENDIX D (continued)

<u>Stream</u>	<u>Sample date</u>	<u>TOT_P (mg/L)</u>	<u>OPHOS_P (mg/L)</u>
Pocatello Creek NF	5/20/1986	0.3	0.031
Pocatello Creek NF	6/3/1986	0.3	0.045
Pocatello Creek NF	3/10/1986	0.4	0.049
Pocatello Creek NF	5/6/1986	0.4	0.039
Pocatello Creek NF	4/22/1986	0.5	0.062
Pocatello Creek NF	4/11/1986	0.9	0.077
Pocatello Creek NF	2/22/1986	1.3	0.077
Pocatello Creek SF	7/8/1986	0.1	0.042
Pocatello Creek SF	2/22/1986	0.2	0.024
Pocatello Creek SF	3/23/1986	0.2	0.065
Pocatello Creek SF	5/6/1986	0.2	0.052
Pocatello Creek SF	5/20/1986	0.2	0.047
Pocatello Creek SF	6/3/1986	0.2	0.07
Pocatello Creek SF	6/17/1986	0.2	0.078
Pocatello Creek SF	3/10/1986	0.3	0.06
Pocatello Creek SF	4/11/1986	0.3	0.063
Pocatello Creek SF	11/18/1985	0.32	0.162
Pocatello Creek SF	4/22/1986	0.4	0.064
Portneuf River	11/15/1990	0.02	0.01
Portneuf River	1/21/1991	0.03	0.03
Portneuf River	3/15/1991	0.06	0.04
Portneuf River	7/15/1999	0.06	0.03
Portneuf River	7/15/1999	0.08	0.04
Portneuf River	7/9/1991	0.13	0.02
Portneuf River	2/25/1999	0.13	0.14
Portneuf River	4/15/1999	0.15	0.1
Portneuf River	7/15/1999	0.15	0.09
Portneuf River	2/25/1999	0.16	0.13
Portneuf River	4/15/1999	0.17	0.05
Portneuf River	5/16/1991	0.19	0.03
Portneuf River	11/21/1991	0.38	0.35
Portneuf River	1/15/1992	0.44	0.39
Portneuf River	3/16/1992	0.49	0.44
Portneuf River	8/2/1977	0.5	0.06
Portneuf River	2/25/1999	0.53	0.5
Portneuf River	5/14/1992	0.56	0.55
Portneuf River	9/28/1992	0.58	0.54
Portneuf River	7/27/1992	0.61	0.58
Portneuf River	8/2/1977	0.8	0.02
Portneuf River	8/2/1977	0.9	0.06
Portneuf River	7/15/1999	0.9	0.86
Portneuf River	8/2/1977	1	0.04
Portneuf River	8/2/1977	3.2	2.02
Portneuf River	8/2/1977	4.1	3.2
Portneuf/Marsh Valley Canal	9/29/1981	0.03	0.03
Portneuf/Marsh Valley Canal	6/19/1981	0.05	0.02
Portneuf/Marsh Valley Canal	8/12/1980	0.06	0.01
Portneuf/Marsh Valley Canal	8/18/1981	0.06	0.03
Portneuf/Marsh Valley Canal	6/25/1980	0.07	0.03
Portneuf/Marsh Valley Canal	5/7/1991	0.07	0.02
Portneuf/Marsh Valley Canal	7/14/1980	0.08	0.02
Portneuf/Marsh Valley Canal	4/15/1981	0.13	0.02
Portneuf/Marsh Valley Canal	6/4/1980	0.21	0.03
Rapid Creek	11/18/1985	0.06	0.039
Rapid Creek	5/6/1986	0.1	0.021
Rapid Creek	6/3/1986	0.1	0.013
Rapid Creek	7/8/1986	0.1	0.041
Rapid Creek	3/23/1986	0.2	0.054
Rapid Creek	4/22/1986	0.2	0.033
Rapid Creek	5/20/1986	0.2	0.023

APPENDIX D (continued)

Stream	Sample_date	TOT_P (mg/L)	OPHOS_P (mg/L)
Rapid Creek	3/10/1986	0.3	0.049
Rapid Creek	4/11/1986	0.3	0.037
Rapid Creek	6/17/1986	0.4	0.127
Rapid Creek	2/22/1986	0.5	0.05
Sorrell Canyon	11/18/1985	0.16	0.067
Sorrell Canyon	3/23/1986	0.2	0.081
Sorrell Canyon	4/22/1986	0.2	0.072
Sorrell Canyon	5/6/1986	0.2	0.073
Sorrell Canyon	6/3/1986	0.2	0.089
Sorrell Canyon	6/17/1986	0.2	0.119
Sorrell Canyon	3/10/1986	0.3	0.085
Sorrell Canyon	5/20/1986	0.3	0.085
Sorrell Canyon	7/8/1986	0.3	0.139
Sorrell Canyon	4/11/1986	0.4	0.066
Sorrell Canyon	2/22/1986	0.8	0.123

APPENDIX E Measured Water Quality Data

1) Measured Summer Water Temperature Data

Stream	Site ID	River km	Temperature (C)				Y-error(+)	Y-error(-)
			Min	Average	Max			
Portneuf River	CMP-5	53.8	13.3	14.25	15.8	1.55	0.95	
Portneuf River	CMP-6	51.4	13.05	16.94	25.77	8.83	3.89	
Portneuf River	Cheyenne Bridge	35.8	15	16.51	20	3.49	1.51	
Portneuf River	CMP-8	33.3	11.1	16.48	21.1	4.62	5.38	
Portneuf River	USGS Station 13075500	28.5	8	18.11	25.5	7.39	10.11	
Portneuf River	CMP-11	22.9	15	16.51	20	3.49	1.51	
Portneuf River	CMP-12	21.5	11	15.9	20	4.1	4.9	
Portneuf River	Siphon Bridge	17.8	11.5	16.12	20	3.88	4.62	
Portneuf River	USGS Station 13075910	16.0	12	14.64	21	6.36	2.64	
Marsh Creek		53.3	13	17.54	28	10.46	4.54	
Rapid Creek		51.5						
Indian Creek		50.7						
Mink Creek		40.0						
Gibson Jack Creek		37.6						
Johnny Creek		36.7						
City Creek		30.9						
Pocatello Creek		26.8	8	11.33	18	6.67	3.33	
Jackson Creek		51.5						
FMC Outfall		21.6	71	79.67	86	6.33	8.67	
WPC Outfall		20.6	18	19.2	20	0.8	1.2	
Batiste Spring		20.0	13.5	15.46	22.2	6.74	1.96	
Papoose Spring		18.3						
Fort Hall Michaud Canal		17.6	12	14.6	16.5	1.9	2.6	

APPENDIX E (continued)

2) Measured Summer DO Data

Stream	Site_ID	River Distance(km)	DO (mg/L)				Y-error (+)	Y-error(-)
			Min	Average	Max			
Portneuf River	CMP-5	53.8	7.1	9.05	11.7	2.65	1.95	
Portneuf River	Cheyenne Bridge	35.8	11.1	11.1	11.1	0	0	
Portneuf River	CMP-8	33.3	5.3	9.7	14.9	5.2	4.4	
Portneuf River	Rainey Park	31.4	6	8.5	11	2.5	2.5	
Portneuf River	CMP-11	25.9	4.6	9.19	14.2	5.01	4.59	
Portneuf River	Batiste Bridge	21.5	4.9	10.02	14.4	4.38	5.12	
Portneuf River	USGS Station 13075909	17.8	4.2	9.25	16.5	7.25	5.05	
Portneuf River	USGS Station 13075910	16	6.1	8.42	11.15	2.73	2.32	
Marsh Creek		53.3	6.5	9.1	16.6	7.5	2.6	
Rapid Creek		51.5						
Indian Creek		50.7						
Mink Creek		40.0		9.07*				
Gibson Jack Creek		37.6						
Johnny Creek		36.7						
City Creek		30.9						
Pocatello Creek		26.8						
Jackson Creek		51.5						
FMC Outfall		21.6	4	6.94	12	5.06	2.94	
WPC Outfall		20.6	6.9	7.32	7.7	0.38	0.42	
Batiste Spring		20.0	8.3	8.96	13.5	4.54	0.66	
Papoose Spring		18.3						
Fort Hall Michaud Canal		17.6						

Note: * Data from DEQ (1999a)

APPENDIX E (continued)

3) Measured Summer BOD5 Data

Stream	SITE_ID	River Distance (km)	BOD5 (mg/l)				Y-error (+)	Y-error (-)
			Min	Average	Max			
Portneuf River	CMP-5	53.8	0.6	4.08	8.8	3*	3.48	
Portneuf River	Station 1	35.8	0.4	0.4	0.4	0	0	
Portneuf River	CMP-8	33.3	0.3	3.25	8	3*	2.95	
Portneuf River	Rainey Park	31.4	0.33	1.33	4	2.67	1	
Portneuf River	Station 2	23.6	0.4	0.4	0.4	0	0	
Portneuf River	CMP-11	22.9	0.2	3.08	6.5	3.42	2.88	
Portneuf River	Station 3	22.0	0.4	0.4	0.4	0	0	
Portneuf River	CMP-12	21.5	1.7	3.05	5	1.95	1.35	
Portneuf River	Station 7	21.0	0.4	0.4	0.4	0	0	
Portneuf River	Station 6	20.7	0.8	0.8	0.8	0	0	
Portneuf River	USGS Station 13075909	17.8	0.8	4.36	12.4	3*	3.56	
Marsh Creek		53.3	2	4.36	7.9	3.54	2.36	
Rapid Creek		51.5						
Indian Creek		50.7						
Mink Creek		40.0		0.4**				
Gibson Jack Creek		37.6						
Johnny Creek		36.7						
City Creek		30.9		2.48				
Pocatello Creek		26.8						
Jackson Creek		51.5						
FMC Outfall		21.6	1.2	2.41	5.4	2.99	1.21	
WPC Outfall		20.6	5	7.26	13	5.74	2.26	
Batiste Spring		20.0	0.4	3.44	6.1	2.66	3.04	
Papoose Spring		18.3		3.44***				
Fort Hall Michaud Canal		17.6						

Note: * To get rid of big error bars, error (+)=3

** Data from DEQ (1999a)

*** Assumed to be equal to the data of Batiste Spring

APPENDIX E (continued)

4) Measured Summer Data of ON_N

Stream	Site_ID	River_km	ON_N(mg/L)			Y-error (+)	Y-error (-)
			Min	Average	Max		
Portneuf River	USGS Station 13075500	28.5	0.40	0.54	1.00	0.46	0.14
Portneuf River	CMP-12	21.5	0.40	0.54	1.00	0.46	0.14
Portneuf River	T-6	20.2	0.11	0.11	0.11	0.00	0.00
Portneuf River	T-7	19.8	0.15	0.15	0.15	0.00	0.00
Portneuf River	T-8	19.2	0.19	0.19	0.19	0.00	0.00
Portneuf River	T-9	18.8	0.13	0.13	0.13	0.00	0.00
Portneuf River	T-10	18.2	0.073	0.073	0.073	0.00	0.00
Portneuf River	Siphon Bridge	17.8	0.4	0.74	1.17	0.43	0.34
Portneuf River	USGS Station 13075910	16.0	0.11	0.27	0.56	0.29	0.16
Marsh Creek		53.3	0.39	0.85	1.9		
Rapid Creek		51.5	0.34	0.55	0.96		
Indian Creek		50.7	0.31	0.36	0.45		
Mink Creek		40.0					
Gibson Jack Creek		37.6					
Johnny Creek		36.7					
City Creek		30.9					
Pocatello Creek		26.8	0.29	0.55	0.82	0.26	0.26
Jackson Creek		51.5	0.26	0.37	0.48	0.11	0.11
FMC outfall		21.6					
WPC outfall*		20.6	0	1	2.2	1.20	1.00
Baliste Spring†		20.0	0	0.48	4.79	4.31	0.48
Papoose Spring		18.3					
Fort Hall Michaud Canal		17.6					

Note: * Calculated by KN_N - NH4_N.

APPENDIX E (continued)

5) Measured Summer Data of NH₄-N

Stream	Site ID	River km	NH ₄ -N(mg/L)			Y-error (+)	Y-error (-)
			Min	Average	Max		
Portneuf River	USGS Station 13075500	28.5	0.1	0.2	0.3	0.1	0.1
Portneuf River	T-1	21.7	0.014	0.014	0.014	0	0
Portneuf River	CMP-12	21.5	0.1	0.2	0.3	0.1	0.1
Portneuf River	T-2	21.3	0.114	0.114	0.114	0	0
Portneuf River	T-3	21.0	0.417	0.417	0.417	0	0
Portneuf River	T-4	20.5	0.377	0.377	0.377	0	0
Portneuf River	T-6	20.2	0.382	0.382	0.382	0	0
Portneuf River	T-7	19.8	0.292	0.292	0.292	0	0
Portneuf River	T-8	19.2	0.23	0.23	0.23	0	0
Portneuf River	T-9	18.8	0.275	0.275	0.275	0	0
Portneuf River	T-10	18.2	0.167	0.167	0.167	0	0
Portneuf River	Siphon Bridge	17.8	0.1	0.2	0.3	0.1	0.1
Portneuf River	USGS Station 13075910	16.0	0.09	0.48	0.74	0.26	0.39
Marsh Creek		53.3	0.02	0.097	0.2	0.103	0.077
Rapid Creek		51.5	0.018	0.021	0.026	0.005	0.003
Indian Creek		50.7	0.018	0.027	0.043	0.016	0.009
Mink Creek		40.0		0.9*			
Gibson Jack Creek		37.6		0			
Johnny Creek		36.7		0			
City Creek		30.9		0			
Pocatello Creek		26.8	0.027	0.046	0.085	0.039	0.019
Jackson Creek		51.5	0.008	0.038	0.055	0.017	0.03
FMC outfall		21.6					
WPC outfall**		20.6	0.7	5.375	21	15.625	4.675
Batiste Spring		20.0	0.2	1.09	1.71	0.62	0.89
Papoose Spring		18.3					
Fort Hall Michaud Canal		17.6					

Note: *Data from DEQ(1999a)

**Data from WPC Annual Report

APPENDIX E (continued)

6) Measured Summer data of NO₂_N

Stream	Site ID	River km	NO ₂ _N (mg/L)			Y-error (+)	Y-error (-)
			Min	Average	Max		
Portneuf River	Cheyenne Bridge	35.8	0.01	0.02	0.02	0	0.01
Portneuf River	Rainey Park	31.4	0	0.02	0.02	0	0.02
Portneuf River	USGS Station 13075500	28.5	0	0.01	0.02	0.01	0.01
Portneuf River	Kraft Bridge	25.9	0.01	0.02	0.02	0	0.01
Portneuf River	CMP-12	21.5	0	0.01	0.02	0.01	0.01
Portneuf River	T-2	21.3	0.01	0.01	0.01	0	0
Portneuf River	T-3	21.0	0	0	0	0	0
Portneuf River	T-4	20.5	0	0	0	0	0
Portneuf River	T-6	20.2	0	0	0	0	0
Portneuf River	T-7	19.8	0	0	0	0	0
Portneuf River	T-8	19.2	0	0	0	0	0
Portneuf River	T-9	18.8	0	0	0	0	0
Portneuf River	T-10	18.2	0	0	0	0	0
Portneuf River	Siphon Bridge	17.8	0	0	0.01	0.01	0
Portneuf River	USGS Station 13075910	16.0	0.02	0.052	0.13	0.01*	0.01*
Marsh Creek		53.3	0.01	0.02	0.03		
Rapid Creek		51.5		0			
Indian Creek		50.7	0	0	0.01		
Mink Creek		40.0					
Gibson Jack Creek		37.6					
Johnny Creek		36.7					
City Creek		30.9					
Pocatello Creek		26.8	0	0	0.014	0.014	0
Jackson Creek		51.5	0.01	0.01	0.02	-0.01	0
FMC outfall		21.6					
WPC outfall		20.6					
Batiste Spring		20.0					
Papoose Spring		18.3					
Fort Hall Michaud Canal		17.6					

Note: * To get rid of big error bars, error=ave +- 0.01

APPENDIX E (continued)

7) Measured Summer Data of NO₃-N

Stream	Site ID	River km	NO ₃ -N (mg/L)			
			Min	Average	Max	Y-error (+)
Portneuf River	Cheyenne Bridge*	35.8	0.18	0.78	1.29	0.51
Portneuf River	Rainey Park	31.4	0.2	0.68	1.72	1.04
Portneuf River	USGS Station 13075500*	28.5	0.14	0.94	2.41	1.47
Portneuf River	Kraft Bridge*	25.9	0.17	0.77	1.26	0.49
Portneuf River	T-1	21.7	0.014	0.014	0.014	0
Portneuf River	CMP-12*	21.5	0.14	0.94	2.41	1.47
Portneuf River	T-2*	21.3	1.13	1.13	1.13	0
Portneuf River	T-3**	21.0	2.53	2.53	2.53	0
Portneuf River	T-4**	20.5	2.6	2.6	2.6	0
Portneuf River	T-6**	20.2	2.71	2.71	2.71	0
Portneuf River	T-7**	19.8	2.62	2.62	2.62	0
Portneuf River	T-8**	19.2	2.7	2.7	2.7	0
Portneuf River	T-9**	18.8	2.71	2.71	2.71	0
Portneuf River	T-10**	18.2	2.71	2.71	2.71	0
Portneuf River	Siphon Bridge*	17.8	0.92	1.92	2.67	0.75
Portneuf River	USGS Station 13075910	16.0	1.68	2.02	2.57	0.55
Marsh Creek		53.3	0.07	0.33	0.77	
Rapid Creek		51.5	0.44	0.98	1.28	
Indian Creek		50.7	1.02	1.6	1.93	
Mink Creek		40.0		0.082***		
Gibson Jack Creek		37.6				
Johnny Creek		36.7		0.008		
City Creek		30.9		0.091		
Pocatello Creek*		26.8	0.76	1.69	2.34	
Jackson Creek*		51.5	0.34	1.48	3.18	
FMC outfall		21.6	1.02	1.26	1.49	
WPC outfall		20.6	8.6	13.03	18.9	
Batiste Spring		20.0	1.5	5.17	12.8	
Papoose Spring		18.3	1	1.1	1.2	
Fort Hall Michaud Canal		17.6				

Note: * NO₃-N calculated from NO₂₃-N data by equation *** (In Chapter III)** Assume NO₂-N equal to 0, NO₃-N= NO₂₃-N

*** Data from DEQ(1999a)

APPENDIX E (continued)

10) Measured Summer Data of TOT_P

Stream	Site ID	River_km	TOT_P (mg/L)			Y-error (+)	Y-error (-)
			Min	Average	Max		
Portneuf River	CMP-5	53.8	0.08	0.22	0.48	0.26	0.14
Portneuf River	Cheyenne Bridge	35.8	0.05	0.1	0.23	0.13	0.05
Portneuf River	CMP-8	33.3	0.02	0.22	0.45	0.23	0.2
Portneuf River	Rainey Park	31.4	0.15	0.32	0.75	0.43	0.17
Portneuf River	CMP-10	29.0	0.04	0.12	0.26	0.14	0.08
Portneuf River	USGS Station 13075500	28.5	0.013	0.089	0.41	0.321	0.076
Portneuf River	Kraft Bridge	25.9	0.1	0.16	0.22	0.06	0.06
Portneuf River	CMP-11	22.9	0.02	0.245	0.38	0.135	0.225
Portneuf River	T-1	21.7	0.044	0.044	0.044	0	0
Portneuf River	CMP-12	21.5	0.06	0.85	2.45	1.6	0.79
Portneuf River	T-2	21.3	1.3	1.3	1.3	0	0
Portneuf River	T-3	21.0	2.07	2.07	2.07	0	0
Portneuf River	T-4	20.5	2.06	2.06	2.06	0	0
Portneuf River	T-6	20.2	1.9	1.9	1.9	0	0
Portneuf River	T-7	19.8	1.47	1.47	1.47	0	0
Portneuf River	T-8	19.2	1.45	1.45	1.45	0	0
Portneuf River	T-9	18.8	1.44	1.44	1.44	0	0
Portneuf River	T-10	18.2	1.21	1.21	1.21	0	0
Portneuf River	CMP-13	17.8	0.52	1.00	1.59	0.59	0.48
Portneuf River	USGS Station 13075910	16.0	0.44	0.59	0.77	0.18	0.15
Marsh Creek		53.3	0.07	0.12	0.4	0.28	0.05
Rapid Creek		51.5	0.1	0.18	0.4	0.22	0.08
Indian Creek		50.7	0.1	0.29	1.1	0.81	0.19
Mink Creek		40.0		0.58*			
Gibson Jack Creek		37.6		0.046**			
Johnny Creek		36.7		0.046**			
City Creek		30.9		0.029			
Pocatello Creek		26.8	0.04	0.16	0.3	0.14	0.12
Jackson Creek		51.5	0.1	0.13	0.2	0.07	0.03
FMC Outfall		21.6	5.36	8.23	11	2.77	2.87
WPC Outfall		20.6	0.6	1.48	2.9	1.42	0.88
Batiste Spring		20.0	0.02	2.22	9.8	7.58	2.2
Papoose Spring***		18.3	0.33	0.39	0.51	0.12	0.06
Fort Hall Michaud Canal		17.6					

Note: * Data from DEQ(1999a)

** Data from Chen (2001)

APPENDIX E (continued)

9) Measured Summer Data of OPHOS_P (DIS_P)

Stream	Site ID	River km	OPHOS_P (mg/L)			
			Min	Average	Max	Y-error (+)
Portneuf River	CMP-5*	53.8	0	0.05	0.26	0.21
Portneuf River	Cheyenne Bridge	35.8	0.02	0.16	0.37	0.21
Portneuf River	CMP-8*	33.3	0	0.05	0.23	0.18
Portneuf River	Rainey Park*	31.4	0.03	0.13	0.47	0.34
Portneuf River	CMP-10*	29.0	0.02	0.05	0.08	0.03
Portneuf River	USGS Station 13075500	28.5	0.01	0.03	0.07	0.04
Portneuf River	Kraft Bridge	25.9	0.05	0.07	0.09	0.02
Portneuf River	CMP-11*	22.9	0.01	0.07	0.18	0.11
Portneuf River	T-1	21.7	0.008	0.01	0.01	0.00
Portneuf River	CMP-12	21.5	0.02	0.08	0.26	0.18
Portneuf River	T-2	21.3	0.89	0.89	0.89	0.00
Portneuf River	T-3	21.0	1.93	1.93	1.93	0.00
Portneuf River	T-4	20.5	1.88	1.88	1.88	0.00
Portneuf River	T-6	20.2	1.80	1.80	1.80	0.00
Portneuf River	T-7	19.8	1.36	1.36	1.36	0.00
Portneuf River	T-8	19.2	1.33	1.33	1.33	0.00
Portneuf River	T-9	18.8	1.35	1.35	1.35	0.00
Portneuf River	T-10	18.2	1.18	1.18	1.18	0.00
Portneuf River	CMP-13	17.8	0.50	0.94	1.46	0.52
Portneuf River	USGS Station 13075910	16.0	0.46	0.57	0.77	0.20
Marsh Creek		53.3	0.01	0.03	0.06	0.03
Rapid Creek		51.5	0.01	0.05	0.13	0.08
Indian Creek		50.7	0.03	0.04	0.04	0.01
Mink Creek		40.0		0.34		
Gibson Jack Creek		37.6		0.02		
Johnny Creek		36.7		0.02		
City Creek		30.9		0.01		
Pocatello Creek		26.8	0.03	0.07	0.13	0.06
Jackson Creek		51.5	0.02	0.06	0.11	0.05
FMC Outfall*		21.6	4.09	4.30	8.52	4.22
WPC Outfall		20.6	0.16	0.44	1.14	0.70
Batiste Spring		20.0	1.04	1.91	3.00	1.09
Papoose Spring		18.3	0.14	0.19	0.28	0.09
Fort Hall Michaud Canal		17.6				

Note: * Calculated data from TOT_P

APPENDIX E (continued)

10) Measured Summer Data of TOT_P

Stream	Site ID	River km	TOT_P (mg/L)			Y-error (+)	Y-error (-)
			Min	Average	Max		
Portneuf River	CMP-5	53.8	0.08	0.22	0.48	0.26	0.14
Portneuf River	Cheyenne Bridge	35.8	0.05	0.1	0.23	0.13	0.05
Portneuf River	CMP-8	33.3	0.02	0.22	0.45	0.23	0.2
Portneuf River	Rainey Park	31.4	0.15	0.32	0.75	0.43	0.17
Portneuf River	CMP-10	29.0	0.04	0.12	0.26	0.14	0.08
Portneuf River	USGS Station 13075500	28.5	0.013	0.089	0.41	0.321	0.076
Portneuf River	Kraft Bridge	25.9	0.1	0.16	0.22	0.06	0.06
Portneuf River	CMP-11	22.9	0.02	0.245	0.38	0.135	0.225
Portneuf River	T-1	21.7	0.044	0.044	0.044	0	0
Portneuf River	CMP-12	21.5	0.06	0.85	2.45	1.6	0.79
Portneuf River	T-2	21.3	1.3	1.3	1.3	0	0
Portneuf River	T-3	21.0	2.07	2.07	2.07	0	0
Portneuf River	T-4	20.5	2.06	2.06	2.06	0	0
Portneuf River	T-6	20.2	1.9	1.9	1.9	0	0
Portneuf River	T-7	19.8	1.47	1.47	1.47	0	0
Portneuf River	T-8	19.2	1.45	1.45	1.45	0	0
Portneuf River	T-9	18.8	1.44	1.44	1.44	0	0
Portneuf River	T-10	18.2	1.21	1.21	1.21	0	0
Portneuf River	CMP-13	17.8	0.52	1.00	1.59	0.59	0.48
Portneuf River	USGS Station 13075910	16.0	0.44	0.59	0.77	0.18	0.15
Marsh Creek		53.3	0.07	0.12	0.4	0.28	0.05
Rapid Creek		51.5	0.1	0.18	0.4	0.22	0.08
Indian Creek		50.7	0.1	0.29	1.1	0.81	0.19
Mink Creek		40.0		0.58*			
Gibson Jack Creek		37.6		0.046**			
Johnny Creek		36.7		0.046**			
City Creek		30.9		0.029			
Pocatello Creek		26.8	0.04	0.16	0.3	0.14	0.12
Jackson Creek		51.5	0.1	0.13	0.2	0.07	0.03
FMC Outfall		21.6	5.36	8.23	11	2.77	2.87
WPC Outfall		20.6	0.6	1.48	2.9	1.42	0.88
Batiste Spring		20.0	0.02	2.22	9.8	7.58	2.2
Papooose Spring***		18.3	0.33	0.39	0.51	0.12	0.06
Fort Hall Michaud Canal		17.6					

Note: * Data from DEQ(1999a)

** Data from Chen (2001)

APPENDIX E (continued)

11) Estimated Summer Data of Chlorophyll a

Stream	Site_ID	River_km	Ave Chl a (ug/l)			Y-error (+)	Y-error (-)
			Min	Average	Max		
Portneuf River	CMP-5	33.44	28.72	98.89	273.7	174.81	70.17
Portneuf River	Cheyenne Bridge	22.22	16.79	37.38	104.65	67.27	20.59
Portneuf River	CMP-8	20.66	6.33	98.89	251.15	152.26	92.56
Portneuf River	Rainey Park	19.49	61.17	160.27	499.72	339.45	99.1
Portneuf River	CMP-10	18.01	13.13	46.55	122.46	75.91	33.42
Portneuf River	USGS Station 13075500	17.71	4.13	32.56	221.97	189.41	28.43
Portneuf River	Kraft Bridge	16.12	37.38	66.26	98.89	32.63	28.88
Portneuf River	CMP-11	14.22	6.33	113.46	200.78	87.32	107.13
Portneuf River	T-1	13.46	14.57	14.57	14.57	0	0
Portneuf River	CMP-12	13.35	20.62	592.89	2589.69	1000*	572.27
Portneuf River	T-2	13.23	1065.49	1065.49	1065.49	0	0
Portneuf River	T-3	13.03	2042.11	2042.11	2042.11	0	0
Portneuf River	T-4	12.73	2028.24	2028.24	2028.24	0	0
Portneuf River	T-6	12.52	1810.4	1810.4	1810.4	0	0
Portneuf River	T-7	12.28	1264.28	1264.28	1264.28	0	0
Portneuf River	T-8	11.91	1240.36	1240.36	1240.36	0	0
Portneuf River	T-9	11.65	1228.46	1228.46	1228.46	0	0
Portneuf River	T-10	11.30	964.52	964.52	964.52	0	0
Portneuf River	CMP-13	11.05	304.62	555.06	741.15	186.09	250.44
Portneuf River	USGS Station 13075910	9.97	166.84	289.04	517.98	228.94	122.2

Note: *To get rid of big error bars, error(+) = 1000

APPENDIX E (continued)

12) Measured Cl Data

			Cl (mg/L)				
Stream	Site ID	River km	Min	Average	Max	Y-error(+)	Y-error(-)
Portneuf River*	CMP-5	53.8	25.84	35.07	44.3	9.23	9.23
Portneuf River	CMP-6	51.4	42.9	43.1	43.3	0.2	0.2
Portneuf River*		41.5	28.2	39.23	45.8	6.57	11.03
Portneuf River	Cheyenne Bridge	35.8	22	39.13	46	6.87	17.13
Portneuf River	USGS Station 13075500	28.5	16	37.82	57	19.18	21.82
Portneuf River	Kraft Bridge	25.9	20	38.89	52	13.11	18.89
Portneuf River	CMP-11	22.9	40	40	40	0	0
Portneuf River	CMP-12	21.5	20	35.25	45	9.75	15.25
Portneuf River	Siphon Bridge	17.8	26	39.15	50	10.85	13.15
Portneuf River	USGS Station 13075910	16.0	19	36.86	49	12.14	17.86
Portneuf River	Downstream	13.5	37.5	38.17	38.7	0.53	0.67
Marsh Creek		53.3	10	50.07	100	49.93	40.07
Rapid Creek		51.5	13.1	15.8	18.1	2.3	2.7
Indian Creek*		50.7	80.1	86.05	92	5.95	5.95
Mink Creek*		40.0	25.7	26.55	27.4	0.85	0.85
Gibson Jack Creek*		37.6	10.5	10.65	10.8	0.15	0.15
Johnny Creek*		36.7	88.7	98.35	105	6.65	9.65
City Creek*		30.9	11.8	12.8	13.8	1	1
Pocatello Creek		26.8	16	55.23	126	70.77	39.23
Jackson Creek		51.5					
FMC outfall		21.6					
WPC outfall**		20.6	270	297	398	101	27
Batiste Spring		20.0	24	64.44	89	24.56	40.44
Papoose Spring		18.3	22.5	33.33	50	16.67	10.83
Fort Hall Michaud Canal		17.6				0	0

Note: * Data from Chen (2001)

** Data from the City of Pocatello (2001)

APPENDIX E (continued)

13) Measured Na Data

Stream	Site ID	River km	Na (mg/L)			
			Min	Average	Max	Y-error(+)
Portneuf River*	CMP-5	53.81	32.87	34.05	35.23	1.18
Portneuf River	CMP-6	51.44	35.7	36.25	36.8	0.55
Portneuf River*		41.50	20.7	31.6	37	5.4
Portneuf River	Cheyenne Bridge	35.75	20.2	27.4	34.6	7.2
Portneuf River	USGS Station 13075500	28.51	14	33.18	46	12.82
Portneuf River	CMP-12	21.49	20.7	24.15	27.6	3.45
Portneuf River	USGS Station 13075910	16.04	19	38.71	48	9.29
Portneuf River	Downstream	13.5	37.7	39.13	39.9	0.77
Marsh Creek		53.3	8.7	34.3	59	24.7
Rapid Creek		51.5	12.7	12.95	13.2	0.25
Indian Creek		50.7	18.6	19.45	20.3	0.85
Mink Creek		40.0	16.7	17.3	17.9	0.6
Gibson Jack Creek		37.6	8.82	9.24	9.67	0.43
Johnny Creek		36.7		37.8		
City Creek		30.9	9.29	9.77	10.5	
Pocatello Creek		26.8		26.8		
Jackson Creek		51.5				
FMC outfall		21.6				
WPC outfall		20.6				
Batiste Spring		20.0	39	70.4	95	
Papoose Spring		18.3				
Fort Hall Michaud Canal		17.6	39.1	39.5	39.9	

Note: * Data from Chen (2001)

APPENDIX F Output Data of the Model

Reach Number	Element Number	River Distance (km)	Flow (m ³ /s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
1	1	55.2	0.22	14.56	35.07	34.05	8.96	4
1	2	55.1	0.22	14.84	35.07	34.05	8.87	3.93
1	3	55	0.22	15.1	35.07	34.05	8.78	3.86
1	4	54.9	0.22	15.33	35.07	34.05	8.7	3.78
1	5	54.8	0.22	15.54	35.07	34.05	8.61	3.71
1	6	54.7	0.22	15.73	35.07	34.05	8.52	3.64
1	7	54.6	0.22	15.91	35.07	34.05	8.44	3.57
1	8	54.5	0.22	16.06	35.07	34.05	8.36	3.5
1	9	54.4	0.22	16.2	35.07	34.05	8.28	3.43
1	10	54.3	0.22	16.33	35.07	34.05	8.2	3.36
1	11	54.2	0.22	16.44	35.07	34.05	8.12	3.3
1	12	54.1	0.22	16.55	35.07	34.05	8.05	3.23
1	13	54	0.22	16.64	35.07	34.05	7.98	3.17
1	14	53.9	0.22	16.73	35.07	34.05	7.91	3.11
1	15	53.8	0.22	16.8	35.07	34.05	7.84	3.05
1	16	53.7	0.22	16.87	35.09	34.05	7.78	2.99
1	17	53.6	0.22	16.93	35.16	34.05	7.72	2.93
1	18	53.5	0.22	17	35.53	34.06	7.68	2.9
1	19	53.4	0.22	17.1	37.48	34.09	7.7	3
3	1	53.3	1.18	17.45	47.54	34.26	8.12	3.75
3	2	53.2	1.18	17.45	47.54	34.26	8.07	3.71
3	3	53.1	1.18	17.45	47.54	34.26	8.03	3.67
3	4	53	1.18	17.46	47.54	34.26	7.98	3.63
3	5	52.9	1.18	17.46	47.54	34.26	7.94	3.58
3	6	52.8	1.18	17.46	47.54	34.26	7.89	3.54
3	7	52.7	1.18	17.46	47.54	34.26	7.85	3.5
3	8	52.6	1.18	17.46	47.54	34.26	7.81	3.46
3	9	52.5	1.18	17.46	47.54	34.26	7.77	3.42
3	10	52.4	1.18	17.46	47.54	34.26	7.73	3.38
3	11	52.3	1.18	17.47	47.54	34.26	7.69	3.34
3	12	52.2	1.18	17.47	47.54	34.26	7.65	3.31
3	13	52.1	1.18	17.47	47.54	34.26	7.62	3.27
3	14	52	1.18	17.47	47.52	34.25	7.58	3.23
3	15	51.9	1.18	17.47	47.49	34.22	7.55	3.19
3	16	51.8	1.18	17.47	47.36	34.14	7.52	3.14
3	17	51.7	1.18	17.46	46.91	33.84	7.51	3.07
3	18	51.6	1.18	17.43	45.34	32.78	7.57	2.9
6	1	51.5	1.33	17.33	39.81	29.07	7.85	2.41
6	2	51.4	1.33	17.33	39.81	29.07	7.82	2.38
6	3	51.3	1.33	17.34	39.81	29.07	7.79	2.36
6	4	51.2	1.33	17.34	39.82	29.07	7.76	2.33
6	5	51.1	1.33	17.35	39.83	29.07	7.74	2.31
6	6	51	1.33	17.35	39.87	29.06	7.71	2.28
6	7	50.9	1.33	17.36	40	29.03	7.7	2.25
6	8	50.8	1.33	17.36	40.45	28.94	7.74	2.21

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m3/s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
8	1	50.7	1.35	17.36	41.98	28.62	7.91	2.14
8	2	50.6	1.35	17.36	41.98	28.62	7.92	2.13
8	3	50.5	1.35	17.37	41.98	28.62	7.93	2.12
8	4	50.4	1.35	17.37	41.98	28.62	7.94	2.11
8	5	50.3	1.35	17.37	41.98	28.62	7.95	2.1
8	6	50.2	1.35	17.38	41.98	28.62	7.96	2.09
8	7	50.1	1.35	17.38	41.98	28.62	7.97	2.08
8	8	50	1.35	17.38	41.98	28.62	7.98	2.07
8	9	49.9	1.35	17.39	41.98	28.62	7.99	2.06
8	10	49.8	1.35	17.39	41.98	28.62	7.99	2.05
8	11	49.7	1.35	17.39	41.98	28.62	8	2.04
8	12	49.6	1.35	17.4	41.98	28.62	8.01	2.03
8	13	49.5	1.35	17.4	41.98	28.62	8.02	2.02
8	14	49.4	1.35	17.4	41.98	28.62	8.02	2.01
8	15	49.3	1.35	17.41	41.98	28.62	8.03	2
8	16	49.2	1.35	17.41	41.98	28.62	8.04	1.99
8	17	49.1	1.35	17.41	41.98	28.62	8.04	1.98
8	18	49	1.35	17.41	41.98	28.62	8.05	1.97
8	19	48.9	1.35	17.42	41.98	28.62	8.06	1.96
9	1	48.8	1.35	17.42	41.98	28.62	8.06	1.95
9	2	48.7	1.35	17.42	41.98	28.62	8.07	1.94
9	3	48.6	1.35	17.42	41.98	28.62	8.08	1.93
9	4	48.5	1.35	17.43	41.98	28.62	8.08	1.93
9	5	48.4	1.35	17.43	41.98	28.62	8.09	1.92
9	6	48.3	1.35	17.43	41.98	28.62	8.09	1.91
9	7	48.2	1.35	17.43	41.98	28.62	8.1	1.9
9	8	48.1	1.35	17.43	41.98	28.62	8.1	1.89
9	9	48	1.35	17.44	41.98	28.62	8.11	1.88
9	10	47.9	1.35	17.44	41.98	28.62	8.11	1.87
9	11	47.8	1.35	17.44	41.98	28.62	8.12	1.86
9	12	47.7	1.35	17.44	41.98	28.62	8.12	1.85
9	13	47.6	1.35	17.44	41.98	28.62	8.13	1.84
9	14	47.5	1.35	17.44	41.98	28.62	8.13	1.84
9	15	47.4	1.35	17.45	41.98	28.62	8.14	1.83
9	16	47.3	1.35	17.45	41.98	28.62	8.14	1.82
9	17	47.2	1.35	17.45	41.98	28.62	8.15	1.81
9	18	47.1	1.35	17.45	41.98	28.62	8.15	1.8
9	19	47	1.35	17.45	41.98	28.62	8.15	1.79
10	1	46.9	1.35	17.45	41.98	28.62	8.16	1.78
10	2	46.8	1.35	17.46	41.98	28.62	8.16	1.78
10	3	46.7	1.35	17.46	41.98	28.62	8.17	1.77
10	4	46.6	1.35	17.46	41.98	28.62	8.17	1.76
10	5	46.5	1.35	17.46	41.98	28.62	8.17	1.75
10	6	46.4	1.35	17.46	41.98	28.62	8.18	1.74
10	7	46.3	1.35	17.46	41.98	28.62	8.18	1.73
10	8	46.2	1.35	17.46	41.98	28.62	8.18	1.73

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m3/s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
10	9	46.1	1.35	17.46	41.98	28.62	8.19	1.72
10	10	46	1.35	17.47	41.98	28.62	8.19	1.71
10	11	45.9	1.35	17.47	41.98	28.62	8.19	1.7
10	12	45.8	1.35	17.47	41.98	28.62	8.2	1.69
10	13	45.7	1.35	17.47	41.98	28.62	8.2	1.69
10	14	45.6	1.35	17.47	41.98	28.62	8.2	1.68
10	15	45.5	1.35	17.47	41.98	28.62	8.21	1.67
10	16	45.4	1.35	17.47	41.98	28.62	8.21	1.66
10	17	45.3	1.35	17.47	41.98	28.62	8.21	1.65
10	18	45.2	1.35	17.47	41.98	28.62	8.22	1.65
10	19	45.1	1.35	17.47	41.98	28.62	8.22	1.64
11	1	45	1.35	17.47	41.98	28.62	8.22	1.63
11	2	44.9	1.35	17.48	41.98	28.62	8.22	1.62
11	3	44.8	1.35	17.48	41.98	28.62	8.23	1.61
11	4	44.7	1.35	17.48	41.98	28.62	8.23	1.61
11	5	44.6	1.35	17.48	41.98	28.62	8.23	1.6
11	6	44.5	1.35	17.48	41.98	28.62	8.23	1.59
11	7	44.4	1.35	17.48	41.98	28.62	8.24	1.58
11	8	44.3	1.35	17.48	41.98	28.62	8.24	1.58
11	9	44.2	1.35	17.48	41.98	28.62	8.24	1.57
11	10	44.1	1.35	17.48	41.98	28.62	8.24	1.56
11	11	44	1.35	17.48	41.98	28.62	8.25	1.55
11	12	43.9	1.35	17.48	41.98	28.62	8.25	1.55
11	13	43.8	1.35	17.48	41.98	28.62	8.25	1.54
11	14	43.7	1.35	17.48	41.98	28.62	8.25	1.53
11	15	43.6	1.35	17.48	41.98	28.62	8.26	1.53
11	16	43.5	1.35	17.48	41.98	28.62	8.26	1.52
11	17	43.4	1.35	17.49	41.98	28.62	8.26	1.51
11	18	43.3	1.35	17.49	41.98	28.62	8.26	1.5
11	19	43.2	1.35	17.49	41.98	28.62	8.26	1.5
12	1	43.1	1.35	17.49	41.98	28.62	8.27	1.49
12	2	43	1.35	17.49	41.98	28.62	8.27	1.48
12	3	42.9	1.35	17.49	41.98	28.62	8.27	1.48
12	4	42.8	1.35	17.49	41.98	28.62	8.27	1.47
12	5	42.7	1.35	17.49	41.98	28.62	8.27	1.46
12	6	42.6	1.35	17.49	41.98	28.62	8.27	1.45
12	7	42.5	1.35	17.49	41.98	28.62	8.28	1.45
12	8	42.4	1.35	17.49	41.98	28.62	8.28	1.44
12	9	42.3	1.35	17.49	41.98	28.62	8.28	1.43
12	10	42.2	1.35	17.49	41.98	28.62	8.28	1.43
12	11	42.1	1.35	17.49	41.98	28.62	8.28	1.42
12	12	42	1.35	17.49	41.98	28.62	8.28	1.41
12	13	41.9	1.35	17.49	41.98	28.62	8.29	1.41
12	14	41.8	1.35	17.49	41.98	28.62	8.29	1.4
12	15	41.7	1.35	17.49	41.98	28.62	8.29	1.39
12	16	41.6	1.35	17.49	41.98	28.62	8.29	1.39

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m ³ /s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
12	17	41.5	1.35	17.49	41.98	28.62	8.29	1.38
12	18	41.4	1.35	17.49	41.98	28.62	8.29	1.37
12	19	41.3	1.35	17.49	41.98	28.62	8.3	1.37
13	1	41.2	1.35	17.49	41.98	28.62	8.3	1.36
13	2	41.1	1.35	17.49	41.98	28.62	8.3	1.35
13	3	41	1.35	17.49	41.98	28.62	8.3	1.35
13	4	40.9	1.35	17.49	41.98	28.62	8.3	1.34
13	5	40.8	1.35	17.49	41.98	28.62	8.3	1.33
13	6	40.7	1.35	17.5	41.98	28.62	8.3	1.33
13	7	40.6	1.35	17.5	41.98	28.62	8.31	1.32
13	8	40.5	1.35	17.5	41.98	28.62	8.31	1.32
13	9	40.4	1.35	17.5	41.98	28.62	8.31	1.31
13	10	40.3	1.35	17.49	41.97	28.61	8.31	1.3
13	11	40.2	1.35	17.49	41.91	28.57	8.31	1.29
13	12	40.1	1.35	17.44	41.56	28.31	8.33	1.27
15	1	40	1.5	17.16	39.58	26.86	8.44	1.15
15	2	39.9	1.5	17.17	39.58	26.86	8.43	1.14
15	3	39.8	1.5	17.18	39.58	26.86	8.41	1.13
15	4	39.7	1.5	17.19	39.58	26.86	8.4	1.12
15	5	39.6	1.5	17.2	39.58	26.86	8.39	1.12
15	6	39.5	1.5	17.2	39.58	26.86	8.37	1.11
15	7	39.4	1.5	17.21	39.58	26.86	8.36	1.1
15	8	39.3	1.5	17.22	39.58	26.86	8.35	1.09
15	9	39.2	1.5	17.23	39.58	26.86	8.33	1.09
15	10	39.1	1.5	17.23	39.58	26.86	8.32	1.08
15	11	39	1.5	17.24	39.58	26.86	8.31	1.07
15	12	38.9	1.5	17.25	39.58	26.86	8.3	1.06
15	13	38.8	1.5	17.25	39.58	26.86	8.29	1.06
15	14	38.7	1.5	17.26	39.58	26.86	8.27	1.05
15	15	38.6	1.5	17.26	39.58	26.86	8.26	1.04
15	16	38.5	1.5	17.27	39.58	26.86	8.25	1.03
15	17	38.4	1.5	17.28	39.58	26.86	8.24	1.03
15	18	38.3	1.5	17.28	39.58	26.86	8.23	1.02
15	19	38.2	1.5	17.29	39.58	26.86	8.22	1.01
16	1	38.1	1.5	17.29	39.58	26.86	8.21	1.01
16	2	38	1.5	17.3	39.57	26.85	8.2	1
16	3	37.9	1.5	17.3	39.53	26.83	8.19	0.99
16	4	37.8	1.5	17.3	39.39	26.74	8.18	0.98
16	5	37.7	1.5	17.26	38.79	26.38	8.19	0.96
18	1	37.6	1.57	17.11	36.37	24.9	8.26	0.91
18	2	37.5	1.57	17.11	36.37	24.9	8.25	0.9
18	3	37.4	1.57	17.12	36.37	24.9	8.24	0.9
18	4	37.3	1.57	17.13	36.37	24.9	8.23	0.89
18	5	37.2	1.57	17.14	36.37	24.9	8.23	0.89
18	6	37.1	1.57	17.15	36.37	24.9	8.22	0.88
18	7	37	1.57	17.16	36.39	24.91	8.21	0.87

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m ³ /s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
18	8	36.9	1.57	17.17	36.44	24.92	8.2	0.87
18	9	36.8	1.57	17.17	36.66	24.96	8.21	0.86
20	1	36.7	1.57	17.17	37.57	25.15	8.28	0.85
20	2	36.6	1.57	17.17	37.57	25.15	8.27	0.84
20	3	36.5	1.57	17.18	37.57	25.15	8.26	0.84
20	4	36.4	1.57	17.19	37.57	25.15	8.25	0.83
20	5	36.3	1.57	17.2	37.57	25.15	8.24	0.83
20	6	36.2	1.57	17.2	37.57	25.15	8.23	0.82
20	7	36.1	1.57	17.21	37.57	25.15	8.23	0.82
20	8	36	1.57	17.22	37.57	25.15	8.22	0.81
20	9	35.9	1.57	17.23	37.57	25.15	8.21	0.81
20	10	35.8	1.57	17.23	37.57	25.15	8.2	0.8
20	11	35.7	1.57	17.24	37.57	25.15	8.19	0.79
20	12	35.6	1.57	17.25	37.57	25.15	8.18	0.79
21	1	35.5	1.57	17.25	37.57	25.15	8.17	0.78
21	2	35.4	1.57	17.26	37.57	25.15	8.16	0.78
21	3	35.3	1.57	17.26	37.57	25.15	8.16	0.77
21	4	35.2	1.57	17.27	37.57	25.15	8.15	0.77
21	5	35.1	1.57	17.28	37.57	25.15	8.14	0.76
21	6	35	1.57	17.28	37.57	25.15	8.13	0.76
21	7	34.9	1.57	17.29	37.57	25.15	8.12	0.75
21	8	34.8	1.57	17.29	37.57	25.15	8.12	0.75
21	9	34.7	1.57	17.3	37.57	25.15	8.11	0.74
21	10	34.6	1.57	17.3	37.57	25.15	8.1	0.74
21	11	34.5	1.57	17.31	37.57	25.15	8.1	0.73
21	12	34.4	1.57	17.31	37.57	25.15	8.09	0.73
21	13	34.3	1.57	17.32	37.57	25.15	8.08	0.72
21	14	34.2	1.57	17.32	37.57	25.15	8.07	0.72
21	15	34.1	1.57	17.33	37.57	25.15	8.07	0.71
21	16	34	1.57	17.33	37.57	25.15	8.06	0.71
21	17	33.9	1.57	17.33	37.57	25.15	8.05	0.7
21	18	33.8	1.57	17.34	37.57	25.15	8.05	0.7
21	19	33.7	1.57	17.34	37.57	25.15	8.04	0.69
22	1	33.6	1.57	17.35	37.57	25.15	8.03	0.69
22	2	33.5	1.57	17.35	37.57	25.15	8.03	0.68
22	3	33.4	1.57	17.35	37.57	25.15	8.02	0.68
22	4	33.3	1.57	17.36	37.57	25.15	8.02	0.68
22	5	33.2	1.57	17.36	37.57	25.15	8.01	0.67
22	6	33.1	1.57	17.36	37.57	25.15	8	0.67
22	7	33	1.57	17.37	37.57	25.15	8	0.66
22	8	32.9	1.57	17.37	37.57	25.15	7.99	0.66
22	9	32.8	1.57	17.37	37.57	25.15	7.99	0.65
22	10	32.7	1.57	17.38	37.57	25.15	7.98	0.65
22	11	32.6	1.57	17.38	37.57	25.15	7.98	0.64
22	12	32.5	1.57	17.38	37.57	25.15	7.97	0.64
22	13	32.4	1.57	17.39	37.57	25.15	7.96	0.64

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m ³ /s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
22	14	32.3	1.57	17.39	37.57	25.15	7.96	0.63
22	15	32.2	1.57	17.39	37.57	25.15	7.95	0.63
22	16	32.1	1.57	17.39	37.57	25.15	7.95	0.62
22	17	32	1.57	17.4	37.57	25.15	7.94	0.62
22	18	31.9	1.57	17.4	37.57	25.15	7.94	0.61
22	19	31.8	1.57	17.4	37.57	25.15	7.93	0.61
23	1	31.7	1.57	17.4	37.57	25.15	7.93	0.61
23	2	31.6	1.57	17.41	37.57	25.15	7.93	0.6
23	3	31.5	1.57	17.41	37.57	25.15	7.92	0.6
23	4	31.4	1.57	17.41	37.57	25.15	7.92	0.59
23	5	31.3	1.57	17.41	37.57	25.15	7.92	0.59
23	6	31.2	1.57	17.42	37.57	25.15	7.93	0.59
24	1	31.1	1.57	17.42	37.56	25.15	7.99	0.58
24	2	31	1.57	17.42	37.49	25.1	8.07	0.59
26	1	30.9	1.59	17.37	36.79	24.67	8.14	0.64
26	2	30.8	1.59	17.37	36.79	24.67	8.21	0.64
26	3	30.7	1.59	17.38	36.79	24.67	8.26	0.64
26	4	30.6	1.59	17.38	36.79	24.67	8.32	0.63
26	5	30.5	1.59	17.39	36.79	24.67	8.37	0.63
26	6	30.4	1.59	17.39	36.79	24.67	8.42	0.63
27	1	30.3	1.59	17.4	36.79	24.67	8.47	0.63
27	2	30.2	1.59	17.4	36.79	24.67	8.52	0.63
27	3	30.1	1.59	17.4	36.79	24.67	8.57	0.63
27	4	30	1.59	17.41	36.79	24.67	8.62	0.62
27	5	29.9	1.59	17.41	36.79	24.67	8.66	0.62
27	6	29.8	1.59	17.41	36.79	24.67	8.7	0.62
27	7	29.7	1.59	17.42	36.79	24.67	8.74	0.62
27	8	29.6	1.59	17.42	36.79	24.67	8.77	0.62
27	9	29.5	1.59	17.42	36.79	24.67	8.81	0.62
27	10	29.4	1.59	17.43	36.79	24.67	8.83	0.62
27	11	29.3	1.59	17.43	36.79	24.67	8.86	0.61
27	12	29.2	1.59	17.43	36.79	24.67	8.89	0.61
27	13	29.1	1.59	17.44	36.79	24.67	8.91	0.61
27	14	29	1.59	17.44	36.79	24.67	8.93	0.61
27	15	28.9	1.59	17.44	36.79	24.67	8.95	0.61
27	16	28.8	1.59	17.44	36.79	24.67	8.97	0.61
28	1	28.7	1.59	17.45	36.79	24.67	8.97	0.6
28	2	28.6	1.59	17.45	36.79	24.67	8.96	0.6
28	3	28.5	1.59	17.45	36.79	24.67	8.95	0.6
28	4	28.4	1.59	17.45	36.79	24.67	8.95	0.6
28	5	28.3	1.59	17.45	36.79	24.67	8.94	0.59
28	6	28.2	1.59	17.46	36.79	24.67	8.93	0.59
28	7	28.1	1.59	17.46	36.79	24.67	8.92	0.59
28	8	28	1.59	17.46	36.79	24.67	8.91	0.59
28	9	27.9	1.59	17.46	36.79	24.67	8.9	0.58
28	10	27.8	1.59	17.46	36.79	24.67	8.9	0.58

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m3/s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
28	11	27.7	1.59	17.46	36.79	24.67	8.89	0.58
28	12	27.6	1.59	17.47	36.79	24.67	8.88	0.58
28	13	27.5	1.59	17.47	36.79	24.67	8.88	0.57
28	14	27.4	1.59	17.47	36.79	24.67	8.87	0.57
28	15	27.3	1.59	17.47	36.79	24.67	8.86	0.57
28	16	27.2	1.59	17.47	36.79	24.67	8.86	0.57
28	17	27.1	1.59	17.47	36.8	24.67	8.85	0.56
28	18	27	1.59	17.45	36.89	24.71	8.85	0.56
28	19	26.9	1.59	17.28	37.53	25.01	8.85	0.55
30	1	26.8	1.9	16	42.14	27.14	8.91	0.5
30	2	26.7	1.91	16.05	42.13	27.19	8.88	0.5
30	3	26.6	1.92	16.1	42.12	27.25	8.85	0.49
30	4	26.5	1.93	16.15	42.12	27.3	8.82	0.48
30	5	26.4	1.93	16.19	42.11	27.35	8.79	0.47
30	6	26.3	1.94	16.23	42.1	27.4	8.76	0.47
30	7	26.2	1.95	16.27	42.1	27.46	8.73	0.46
30	8	26.1	1.96	16.31	42.09	27.51	8.71	0.45
30	9	26	1.96	16.35	42.08	27.56	8.68	0.44
30	10	25.9	1.97	16.38	42.08	27.61	8.66	0.44
30	11	25.8	1.98	16.42	42.07	27.66	8.63	0.43
30	12	25.7	1.98	16.45	42.06	27.71	8.6	0.42
30	13	25.6	1.99	16.48	42.06	27.76	8.58	0.42
30	14	25.5	2	16.51	42.05	27.81	8.55	0.41
30	15	25.4	2.01	16.54	42.04	27.86	8.53	0.4
30	16	25.3	2.01	16.57	42.04	27.91	8.51	0.4
30	17	25.2	2.02	16.59	42.03	27.95	8.48	0.39
30	18	25.1	2.03	16.62	42.03	28	8.46	0.38
30	19	25	2.03	16.64	42.02	28.05	8.44	0.38
31	1	24.9	2.04	16.67	42.01	28.1	8.42	0.37
31	2	24.8	2.05	16.69	42.01	28.14	8.39	0.37
31	3	24.7	2.06	16.71	42	28.19	8.37	0.36
31	4	24.6	2.06	16.73	42	28.24	8.35	0.36
31	5	24.5	2.07	16.75	41.99	28.28	8.33	0.35
31	6	24.4	2.08	16.77	41.98	28.33	8.31	0.34
31	7	24.3	2.09	16.79	41.98	28.37	8.29	0.34
31	8	24.2	2.09	16.81	41.97	28.42	8.27	0.33
31	9	24.1	2.1	16.82	41.97	28.46	8.25	0.33
31	10	24	2.11	16.84	41.96	28.51	8.23	0.32
31	11	23.9	2.11	16.86	41.96	28.55	8.21	0.32
31	12	23.8	2.12	16.87	41.95	28.6	8.2	0.31
31	13	23.7	2.13	16.89	41.94	28.64	8.18	0.31
31	14	23.6	2.14	16.9	41.94	28.68	8.16	0.3
31	15	23.5	2.14	16.91	41.93	28.73	8.14	0.3
31	16	23.4	2.15	16.93	41.93	28.77	8.13	0.3
31	17	23.3	2.16	16.94	41.92	28.81	8.11	0.29
31	18	23.2	2.17	16.95	41.92	28.85	8.1	0.29

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m3/s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
31	19	23.1	2.17	16.96	41.91	28.9	8.1	0.28
32	1	23	2.18	16.97	41.9	28.96	8.14	0.28
32	2	22.9	2.19	16.98	41.9	29.01	8.16	0.28
32	3	22.8	2.2	16.99	41.89	29.06	8.19	0.27
32	4	22.7	2.21	16.99	41.88	29.11	8.21	0.27
32	5	22.6	2.22	17	41.88	29.16	8.24	0.27
32	6	22.5	2.23	17.01	41.87	29.21	8.26	0.27
32	7	22.4	2.24	17.02	41.86	29.26	8.28	0.27
32	8	22.3	2.25	17.02	41.86	29.31	8.3	0.26
32	9	22.2	2.25	17.03	41.85	29.36	8.32	0.26
32	10	22.1	2.26	17.04	41.84	29.41	8.34	0.26
32	11	22	2.27	17.04	41.84	29.45	8.36	0.26
32	12	21.9	2.28	17.07	41.81	29.49	8.37	0.26
32	13	21.8	2.29	17.21	41.65	29.43	8.38	0.26
32	14	21.7	2.37	18.19	40.59	28.76	8.35	0.31
32	15	21.6	2.38	18.11	40.58	29.02	8.36	0.31
33	1	21.5	2.72	17.73	40.55	30.52	8.3	0.27
33	2	21.4	3.05	17.44	40.52	31.69	8.27	0.24
33	3	21.3	3.39	17.21	40.5	32.63	8.26	0.22
33	4	21.2	3.72	17.02	40.48	33.4	8.26	0.2
33	5	21.1	4.06	16.89	40.47	33.96	8.25	0.18
34	1	21	4.23	16.84	40.48	33.97	8.25	0.19
34	2	20.9	4.4	16.81	41.78	33.81	8.19	0.22
34	3	20.8	4.56	16.81	45.5	33.33	8.13	0.33
34	4	20.7	5.07	16.86	54.89	32.11	8.06	0.58
34	5	20.6	5.24	16.82	54.15	32.25	8.04	0.56
35	1	20.5	5.34	16.8	53.65	32.4	8.05	0.55
35	2	20.4	5.45	16.78	53.2	32.66	8.07	0.54
35	3	20.3	5.55	16.75	52.86	33.15	8.09	0.56
35	4	20.2	5.66	16.7	52.72	34.2	8.12	0.62
35	5	20.1	6.47	16.61	53.06	36.6	8.18	0.78
35	6	20	6.57	16.6	52.65	36.59	8.18	0.76
35	7	19.9	6.67	16.59	52.25	36.59	8.19	0.74
35	8	19.8	6.78	16.58	51.86	36.58	8.19	0.72
35	9	19.7	6.88	16.57	51.48	36.57	8.2	0.7
35	10	19.6	6.99	16.57	51.11	36.56	8.21	0.68
35	11	19.5	7.09	16.56	50.75	36.56	8.21	0.66
35	12	19.4	7.2	16.55	50.37	36.55	8.22	0.64
35	13	19.3	7.3	16.54	49.97	36.53	8.22	0.63
36	1	19.2	7.46	16.52	49.47	36.51	8.22	0.61
36	2	19.1	7.62	16.51	48.98	36.47	8.22	0.59
36	3	19	7.77	16.49	48.47	36.39	8.23	0.57
36	4	18.9	7.93	16.47	47.87	36.22	8.23	0.55
37	1	18.8	8.17	16.44	47.07	35.83	8.23	0.53
37	2	18.7	8.42	16.41	46.28	35.44	8.24	0.52
37	3	18.6	8.66	16.38	45.49	35.01	8.24	0.53

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m³/s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
37	4	18.5	8.91	16.33	44.6	34.46	8.26	0.57
37	5	18.4	10.01	16.24	43.44	33.62	8.31	0.7
37	6	18.3	10.25	16.23	42.92	33.39	8.31	0.68
37	7	18.2	10.5	16.22	42.43	33.17	8.31	0.66
37	8	18.1	10.74	16.21	41.98	32.96	8.32	0.64
37	9	18	10.99	16.2	41.6	32.79	8.33	0.62
37	10	17.9	11.23	16.2	41.34	32.67	8.34	0.61
38	1	17.8	11.23	16.22	41.34	32.67	8.36	0.6
38	2	17.7	7.45	16.23	41.34	32.67	8.38	0.6
38	3	17.6	7.45	16.25	41.34	32.67	8.41	0.59
38	4	17.5	7.45	16.27	41.34	32.67	8.44	0.59
38	5	17.4	7.45	16.29	41.34	32.67	8.46	0.58
38	6	17.3	7.45	16.31	41.34	32.67	8.49	0.57
38	7	17.2	7.45	16.33	41.34	32.67	8.52	0.57
38	8	17.1	7.45	16.35	41.34	32.67	8.55	0.56
38	9	17	7.45	16.37	41.34	32.67	8.58	0.55
38	10	16.9	7.45	16.39	41.34	32.67	8.6	0.55
38	11	16.8	7.45	16.4	41.34	32.67	8.63	0.54
38	12	16.7	7.45	16.42	41.34	32.67	8.66	0.53
38	13	16.6	7.45	16.44	41.34	32.67	8.68	0.53
38	14	16.5	7.45	16.46	41.34	32.67	8.71	0.52
38	15	16.4	7.45	16.47	41.34	32.67	8.74	0.52
38	16	16.3	7.45	16.49	41.34	32.67	8.77	0.51
38	17	16.2	7.45	16.51	41.34	32.67	8.79	0.5
38	18	16.1	7.45	16.52	41.34	32.67	8.82	0.5
39	1	16	7.45	16.54	41.34	32.67	8.85	0.49
39	2	15.9	7.45	16.55	41.34	32.67	8.87	0.49
39	3	15.8	7.45	16.57	41.34	32.67	8.9	0.48
39	4	15.7	7.45	16.58	41.34	32.67	8.93	0.48
39	5	15.6	7.45	16.6	41.34	32.67	8.95	0.47
39	6	15.5	7.45	16.61	41.34	32.67	8.98	0.47
39	7	15.4	7.45	16.63	41.34	32.67	9	0.46
39	8	15.3	7.45	16.64	41.34	32.67	9.03	0.45
39	9	15.2	7.45	16.66	41.34	32.67	9.05	0.45
39	10	15.1	7.45	16.67	41.34	32.67	9.08	0.44
39	11	15	7.45	16.68	41.34	32.67	9.11	0.44
39	12	14.9	7.45	16.7	41.34	32.67	9.13	0.43
40	1	14.8	7.45	16.71	41.34	32.67	9.16	0.43
40	2	14.7	7.45	16.72	41.34	32.67	9.18	0.42
40	3	14.6	7.45	16.73	41.34	32.67	9.21	0.42
40	4	14.5	7.45	16.75	41.34	32.67	9.23	0.41
40	5	14.4	7.45	16.76	41.34	32.68	9.26	0.41
40	6	14.3	7.45	16.77	41.34	32.68	9.28	0.4
40	7	14.2	7.45	16.78	41.33	32.69	9.3	0.4
40	8	14.1	7.45	16.78	41.32	32.71	9.32	0.39
40	9	14	7.45	16.78	41.3	32.76	9.33	0.39

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m ³ /s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
40	10	13.9	7.45	16.75	41.24	32.88	9.32	0.37
40	11	13.8	7.45	16.66	41.09	33.17	9.26	0.35
40	12	13.7	7.45	16.44	40.76	33.84	9.09	0.31
40	13	13.6	7.45	15.9	39.99	35.42	8.65	0.22
Marsh Creek								
2	1	1.8	0.97	17.54	50.07	34.3	9.05	4.34
2	2	1.7	0.97	17.54	50.07	34.3	9	4.31
2	3	1.6	0.97	17.54	50.07	34.3	8.95	4.29
2	4	1.5	0.97	17.54	50.07	34.3	8.9	4.27
2	5	1.4	0.97	17.54	50.07	34.3	8.85	4.24
2	6	1.3	0.97	17.54	50.07	34.3	8.8	4.22
2	7	1.2	0.97	17.54	50.07	34.3	8.75	4.2
2	8	1.1	0.97	17.54	50.07	34.3	8.7	4.17
2	9	1	0.97	17.54	50.06	34.3	8.65	4.15
2	10	0.9	0.97	17.54	50.06	34.3	8.6	4.13
2	11	0.8	0.97	17.54	50.05	34.3	8.56	4.1
2	12	0.7	0.97	17.54	50.04	34.3	8.51	4.08
2	13	0.6	0.97	17.54	50.01	34.3	8.46	4.06
2	14	0.5	0.97	17.53	49.95	34.3	8.41	4.03
2	15	0.4	0.97	17.53	49.85	34.3	8.36	4
2	16	0.3	0.97	17.52	49.67	34.29	8.31	3.97
2	17	0.2	0.97	17.51	49.33	34.29	8.25	3.92
2	18	0.1	0.97	17.49	48.7	34.28	8.19	3.86
Rapid Creek								
4	1	2.4	0.04	15.29	15.8	12.95	9.99	0.4
4	2	2.3	0.04	15.21	15.8	12.95	9.99	0.4
4	3	2.2	0.15	15.34	15.8	12.95	9.98	0.4
4	4	2.1	0.15	15.45	15.8	12.95	9.98	0.39
4	5	2	0.15	15.56	15.8	12.95	9.97	0.39
4	6	1.9	0.15	15.66	15.8	12.95	9.96	0.39
4	7	1.8	0.15	15.76	15.8	12.95	9.95	0.39
4	8	1.7	0.15	15.84	15.8	12.95	9.94	0.39
4	9	1.6	0.15	15.92	15.8	12.95	9.93	0.39
4	10	1.5	0.15	16	15.8	12.95	9.91	0.38
4	11	1.4	0.15	16.07	15.8	12.95	9.9	0.38
4	12	1.3	0.15	16.13	15.8	12.95	9.89	0.38
5	1	1.2	0.15	16.19	15.8	12.95	9.88	0.38
5	2	1.1	0.15	16.25	15.8	12.95	9.87	0.38
5	3	1	0.15	16.3	15.8	12.95	9.85	0.37
5	4	0.9	0.15	16.35	15.8	12.95	9.84	0.37
5	5	0.8	0.15	16.39	15.8	12.95	9.83	0.37
5	6	0.7	0.15	16.43	15.8	12.95	9.82	0.37
5	7	0.6	0.15	16.47	15.8	12.95	9.81	0.37
5	8	0.5	0.15	16.5	15.8	12.95	9.79	0.37

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	Flow (m ³ /s)	TEMP (C)	Cl (mg/L)	Na (mg/L)	DO (mg/L)	BOD (mg/L)
5	9	0.4	0.15	16.54	15.8	12.95	9.78	0.36
5	10	0.3	0.15	16.57	15.82	12.96	9.77	0.36
5	11	0.2	0.15	16.6	16.03	13.1	9.75	0.38
5	12	0.1	0.15	16.65	18.14	14.52	9.66	0.56
Indian Creek								
7	1	0.8	0.02	15.56	86.05	19.45	9.97	0.4
7	2	0.7	0.02	15.96	86.05	19.45	9.92	0.39
7	3	0.6	0.02	16.24	86.05	19.45	9.87	0.39
7	4	0.5	0.02	16.44	86.05	19.45	9.82	0.39
7	5	0.4	0.02	16.59	86.05	19.45	9.78	0.39
7	6	0.3	0.02	16.69	86.05	19.45	9.74	0.38
7	7	0.2	0.02	16.77	85.98	19.46	9.71	0.38
7	8	0.1	0.02	16.82	84.34	19.82	9.67	0.45
Mink Creek								
14	1	0.2	0.15	15.15	26.64	17.36	9.14	0.4
14	2	0.1	0.15	15.59	27.66	18.12	9.17	0.45
Gibson Jack Creek								
17	1	0.2	0.07	15.18	10.88	9.38	9.98	0.4
17	2	0.1	0.07	15.67	13.16	10.77	9.86	0.44
Johnny Creek								
19	1	0.2	0.00	15.7	98.26	37.78	9.9	0.4
19	2	0.1	0.00	16.42	95.96	37.3	9.76	0.41
City Creek								
25	1	0.2	0.02	15.26	12.86	9.81	9.98	2.46
25	2	0.1	0.02	15.72	14.07	10.56	9.9	2.35
Pocatello Creek								
29	1	0.7	0.31	11.4	55.23	33	10.01	2.47
29	2	0.6	0.31	11.47	55.23	33	10.02	2.46
29	3	0.5	0.31	11.54	55.23	33	10.03	2.45
29	4	0.4	0.31	11.61	55.22	32.99	10.04	2.44
29	5	0.3	0.31	11.7	55.15	32.97	10.05	2.43
29	6	0.2	0.31	11.93	54.81	32.83	10.03	2.38
29	7	0.1	0.31	12.85	52.97	32.12	9.91	2.18

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
1	1	55.2	0	0.09	0	1.16	0.17	0.05	0.22	98.21
1	2	55.1	0	0.09	0	1.16	0.16	0.05	0.22	97.53
1	3	55	0	0.09	0	1.16	0.16	0.05	0.22	96.85
1	4	54.9	0	0.09	0	1.16	0.16	0.06	0.21	96.17
1	5	54.8	0	0.09	0	1.16	0.16	0.06	0.21	95.49
1	6	54.7	0	0.09	0	1.16	0.15	0.06	0.21	94.81
1	7	54.6	0	0.09	0	1.16	0.15	0.06	0.21	94.13
1	8	54.5	0	0.09	0	1.16	0.15	0.06	0.21	93.46
1	9	54.4	0	0.09	0	1.15	0.14	0.06	0.21	92.79
1	10	54.3	0	0.09	0	1.15	0.14	0.06	0.21	92.12
1	11	54.2	0	0.09	0	1.15	0.14	0.07	0.2	91.45
1	12	54.1	0	0.09	0	1.15	0.14	0.07	0.2	90.79
1	13	54	0	0.09	0	1.15	0.13	0.07	0.2	90.13
1	14	53.9	0	0.09	0	1.15	0.13	0.07	0.2	89.47
1	15	53.8	0	0.08	0	1.15	0.13	0.07	0.2	88.81
1	16	53.7	0	0.08	0	1.15	0.13	0.07	0.2	88.13
1	17	53.6	0	0.08	0	1.15	0.12	0.07	0.2	87.31
1	18	53.5	0.01	0.08	0	1.13	0.12	0.07	0.19	85.7
1	19	53.4	0.06	0.09	0	1.02	0.11	0.07	0.18	80.03
3	1	53.3	0.3	0.11	0	0.47	0.09	0.04	0.13	53.16
3	2	53.2	0.29	0.11	0	0.47	0.09	0.04	0.13	53.05
3	3	53.1	0.29	0.11	0	0.47	0.09	0.04	0.13	52.93
3	4	53	0.29	0.11	0	0.47	0.09	0.04	0.13	52.82
3	5	52.9	0.29	0.11	0	0.47	0.08	0.04	0.13	52.7
3	6	52.8	0.28	0.11	0	0.47	0.08	0.04	0.13	52.59
3	7	52.7	0.28	0.11	0	0.47	0.08	0.04	0.13	52.47
3	8	52.6	0.28	0.11	0	0.47	0.08	0.04	0.13	52.36
3	9	52.5	0.27	0.12	0	0.47	0.08	0.05	0.13	52.25
3	10	52.4	0.27	0.12	0	0.47	0.08	0.05	0.13	52.14
3	11	52.3	0.27	0.12	0	0.47	0.08	0.05	0.12	52.03
3	12	52.2	0.27	0.12	0	0.47	0.08	0.05	0.12	51.92
3	13	52.1	0.26	0.12	0	0.47	0.08	0.05	0.12	51.81
3	14	52	0.26	0.12	0	0.47	0.08	0.05	0.12	51.7
3	15	51.9	0.26	0.12	0	0.47	0.08	0.05	0.12	51.6
3	16	51.8	0.26	0.12	0	0.47	0.07	0.05	0.12	51.5
3	17	51.7	0.25	0.12	0.01	0.49	0.07	0.05	0.12	51.41
3	18	51.6	0.26	0.12	0	0.53	0.07	0.05	0.12	51.36
6	1	51.5	0.27	0.11	0	0.68	0.07	0.05	0.13	51.45
6	2	51.4	0.27	0.11	0	0.68	0.07	0.05	0.13	51.37
6	3	51.3	0.26	0.11	0	0.68	0.07	0.05	0.13	51.28
6	4	51.2	0.26	0.11	0	0.68	0.07	0.05	0.13	51.2
6	5	51.1	0.26	0.11	0	0.68	0.07	0.05	0.13	51.11
6	6	51	0.26	0.11	0	0.68	0.07	0.05	0.12	51.01
6	7	50.9	0.25	0.11	0	0.68	0.07	0.05	0.12	50.87
6	8	50.8	0.25	0.11	0	0.69	0.07	0.05	0.13	50.6

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
8	1	50.7	0.25	0.11	0	0.72	0.08	0.05	0.13	49.88
8	2	50.6	0.25	0.11	0	0.72	0.08	0.05	0.13	49.76
8	3	50.5	0.25	0.11	0	0.72	0.08	0.05	0.13	49.65
8	4	50.4	0.25	0.11	0	0.72	0.08	0.05	0.13	49.54
8	5	50.3	0.25	0.11	0.01	0.72	-0.08	0.06	0.13	49.43
8	6	50.2	0.25	0.11	0.01	0.72	0.08	0.06	0.13	49.32
8	7	50.1	0.25	0.11	0.01	0.72	0.07	0.06	0.13	49.2
8	8	50	0.24	0.11	0.01	0.72	0.07	0.06	0.13	49.09
8	9	49.9	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.98
8	10	49.8	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.87
8	11	49.7	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.76
8	12	49.6	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.65
8	13	49.5	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.54
8	14	49.4	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.43
8	15	49.3	0.24	0.11	0.01	0.72	0.07	0.06	0.13	48.32
8	16	49.2	0.24	0.12	0.01	0.72	0.07	0.06	0.13	48.21
8	17	49.1	0.24	0.12	0.01	0.72	0.07	0.06	0.13	48.1
8	18	49	0.23	0.12	0.01	0.72	0.07	0.06	0.13	48
8	19	48.9	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.89
9	1	48.8	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.78
9	2	48.7	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.67
9	3	48.6	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.57
9	4	48.5	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.46
9	5	48.4	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.35
9	6	48.3	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.25
9	7	48.2	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.14
9	8	48.1	0.23	0.12	0.01	0.72	0.07	0.06	0.13	47.03
9	9	48	0.23	0.12	0.01	0.72	0.07	0.06	0.13	46.93
9	10	47.9	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.82
9	11	47.8	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.72
9	12	47.7	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.61
9	13	47.6	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.51
9	14	47.5	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.41
9	15	47.4	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.3
9	16	47.3	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.2
9	17	47.2	0.22	0.12	0.01	0.72	0.07	0.06	0.13	46.09
9	18	47.1	0.22	0.12	0.01	0.72	0.07	0.06	0.13	45.99
9	19	47	0.22	0.12	0.01	0.72	0.07	0.06	0.13	45.89
10	1	46.9	0.22	0.12	0.01	0.72	0.06	0.06	0.13	45.79
10	2	46.8	0.21	0.12	0.01	0.72	0.06	0.06	0.13	45.68
10	3	46.7	0.21	0.12	0.01	0.72	0.06	0.06	0.13	45.58
10	4	46.6	0.21	0.12	0.01	0.72	0.06	0.06	0.13	45.48
10	5	46.5	0.21	0.12	0.01	0.72	-0.06	0.06	0.13	45.38
10	6	46.4	0.21	0.12	0.01	0.72	0.06	0.06	0.13	45.28
10	7	46.3	0.21	0.12	0.01	0.72	0.06	0.06	0.13	45.18
10	8	46.2	0.21	0.13	0.01	0.72	0.06	0.06	0.13	45.08

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
10	9	46.1	0.21	0.13	0.01	0.72	0.06	0.06	0.12	44.98
10	10	46	0.21	0.13	0.01	0.72	0.06	0.06	0.12	44.88
10	11	45.9	0.21	0.13	0.01	0.72	0.06	0.06	0.12	44.78
10	12	45.8	0.21	0.13	0.01	0.72	0.06	0.06	0.12	44.68
10	13	45.7	0.2	0.13	0.01	0.72	0.06	0.06	0.12	44.58
10	14	45.6	0.2	0.13	0.01	0.72	0.06	0.06	0.12	44.48
10	15	45.5	0.2	0.13	0.01	0.72	0.06	0.06	0.12	44.38
10	16	45.4	0.2	0.13	0.01	0.72	0.06	0.06	0.12	44.28
10	17	45.3	0.2	0.13	0.01	0.72	0.06	0.06	0.12	44.18
10	18	45.2	0.2	0.13	0.01	0.72	0.06	0.06	0.12	44.08
10	19	45.1	0.2	0.13	0.01	0.72	0.06	0.06	0.12	43.99
11	1	45	0.2	0.13	0.01	0.72	0.06	0.06	0.12	43.89
11	2	44.9	0.2	0.13	0.01	0.72	0.06	0.06	0.12	43.79
11	3	44.8	0.2	0.13	0.01	0.72	0.06	0.06	0.12	43.7
11	4	44.7	0.2	0.13	0.01	0.72	0.06	0.06	0.12	43.6
11	5	44.6	0.2	0.13	0.01	0.72	0.06	0.06	0.12	43.5
11	6	44.5	0.19	0.13	0.01	0.72	0.06	0.07	0.12	43.41
11	7	44.4	0.19	0.13	0.01	0.72	0.06	0.07	0.12	43.31
11	8	44.3	0.19	0.13	0.01	0.73	0.06	0.07	0.12	43.21
11	9	44.2	0.19	0.13	0.01	0.73	0.06	0.07	0.12	43.12
11	10	44.1	0.19	0.13	0.01	0.73	0.06	0.07	0.12	43.02
11	11	44	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.93
11	12	43.9	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.83
11	13	43.8	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.74
11	14	43.7	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.64
11	15	43.6	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.55
11	16	43.5	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.46
11	17	43.4	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.36
11	18	43.3	0.19	0.13	0.01	0.73	0.06	0.07	0.12	42.27
11	19	43.2	0.18	0.13	0.01	0.73	0.05	0.07	0.12	42.18
12	1	43.1	0.18	0.13	0.01	0.73	0.05	0.07	0.12	42.08
12	2	43	0.18	0.13	0.01	0.73	0.05	0.07	0.12	41.99
12	3	42.9	0.18	0.13	0.01	0.73	0.05	0.07	0.12	41.9
12	4	42.8	0.18	0.13	0.01	0.73	0.05	0.07	0.12	41.81
12	5	42.7	0.18	0.13	0.01	0.73	0.05	0.07	0.12	41.71
12	6	42.6	0.18	0.13	0.01	0.73	0.05	0.07	0.12	41.62
12	7	42.5	0.18	0.13	0.01	0.73	0.05	0.07	0.12	41.53
12	8	42.4	0.18	0.14	0.01	0.73	0.05	0.07	0.12	41.44
12	9	42.3	0.18	0.14	0.01	0.73	0.05	0.07	0.12	41.35
12	10	42.2	0.18	0.14	0.01	0.73	0.05	0.07	0.12	41.26
12	11	42.1	0.18	0.14	0.01	0.73	0.05	0.07	0.12	41.17
12	12	42	0.18	0.14	0.01	0.73	0.05	0.07	0.12	41.08
12	13	41.9	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.99
12	14	41.8	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.9
12	15	41.7	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.81
12	16	41.6	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.72

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
12	17	41.5	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.63
12	18	41.4	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.54
12	19	41.3	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.45
13	1	41.2	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.36
13	2	41.1	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.28
13	3	41	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.19
13	4	40.9	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.1
13	5	40.8	0.17	0.14	0.01	0.73	0.05	0.07	0.12	40.01
13	6	40.7	0.17	0.14	0.01	0.73	0.05	0.07	0.12	39.92
13	7	40.6	0.17	0.14	0.01	0.73	0.05	0.07	0.12	39.84
13	8	40.5	0.16	0.14	0.01	0.73	0.05	0.07	0.12	39.75
13	9	40.4	0.16	0.14	0.01	0.73	0.05	0.07	0.12	39.67
13	10	40.3	0.16	0.14	0.01	0.73	0.05	0.07	0.12	39.59
13	11	40.2	0.16	0.14	0.01	0.72	0.05	0.07	0.12	39.55
13	12	40.1	0.16	0.16	0.01	0.71	0.05	0.08	0.13	39.77
15	1	40	0.14	0.26	0.01	0.63	0.08	0.11	0.19	41.38
15	2	39.9	0.14	0.26	0.01	0.63	0.08	0.11	0.19	41.33
15	3	39.8	0.13	0.26	0.01	0.63	0.08	0.11	0.19	41.28
15	4	39.7	0.13	0.26	0.01	0.63	0.08	0.11	0.19	41.22
15	5	39.6	0.13	0.26	0.01	0.63	0.08	0.11	0.19	41.17
15	6	39.5	0.13	0.26	0.01	0.63	0.07	0.11	0.19	41.12
15	7	39.4	0.13	0.26	0.01	0.63	0.07	0.11	0.19	41.07
15	8	39.3	0.13	0.26	0.01	0.63	0.07	0.11	0.19	41.02
15	9	39.2	0.13	0.26	0.01	0.63	0.07	0.11	0.19	40.97
15	10	39.1	0.13	0.26	0.01	0.63	0.07	0.12	0.19	40.91
15	11	39	0.13	0.26	0.01	0.63	0.07	0.12	0.19	40.86
15	12	38.9	0.13	0.26	0.01	0.63	0.07	0.12	0.19	40.81
15	13	38.8	0.13	0.26	0.01	0.63	0.07	0.12	0.19	40.76
15	14	38.7	0.13	0.26	0.01	0.63	0.07	0.12	0.19	40.71
15	15	38.6	0.13	0.26	0.01	0.63	0.07	0.12	0.19	40.66
15	16	38.5	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.61
15	17	38.4	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.56
15	18	38.3	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.5
15	19	38.2	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.45
16	1	38.1	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.4
16	2	38	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.34
16	3	37.9	0.12	0.26	0.01	0.63	0.07	0.12	0.19	40.26
16	4	37.8	0.12	0.25	0.01	0.63	0.07	0.12	0.18	40.09
16	5	37.7	0.12	0.25	0.01	0.61	0.07	0.12	0.18	39.53
18	1	37.6	0.11	0.23	0.01	0.56	0.06	0.11	0.17	37.38
18	2	37.5	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.34
18	3	37.4	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.29
18	4	37.3	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.24
18	5	37.2	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.2
18	6	37.1	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.15
18	7	37	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.1

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
18	8	36.9	0.1	0.23	0.01	0.56	0.06	0.11	0.17	37.03
18	9	36.8	0.1	0.23	0.01	0.56	0.06	0.11	0.17	36.9
20	1	36.7	0.1	0.22	0.01	0.55	0.06	0.11	0.17	36.54
20	2	36.6	0.1	0.22	0.01	0.55	0.06	0.11	0.17	36.49
20	3	36.5	0.1	0.22	0.01	0.55	0.06	0.11	0.17	36.44
20	4	36.4	0.1	0.22	0.01	0.55	0.06	0.11	0.17	36.4
20	5	36.3	0.1	0.22	0.01	0.55	0.06	0.11	0.16	36.35
20	6	36.2	0.1	0.22	0.01	0.55	0.06	0.11	0.16	36.3
20	7	36.1	0.09	0.22	0.01	0.55	0.06	0.11	0.16	36.26
20	8	36	0.09	0.22	0.01	0.55	0.05	0.11	0.16	36.21
20	9	35.9	0.09	0.22	0.01	0.55	0.05	0.11	0.16	36.17
20	10	35.8	0.09	0.22	0.01	0.55	0.05	0.11	0.16	36.12
20	11	35.7	0.09	0.22	0.01	0.55	0.05	0.11	0.16	36.07
20	12	35.6	0.09	0.22	0.01	0.55	0.05	0.11	0.16	36.03
21	1	35.5	0.09	0.22	0.01	0.55	0.05	0.11	0.16	35.98
21	2	35.4	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.94
21	3	35.3	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.89
21	4	35.2	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.85
21	5	35.1	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.8
21	6	35	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.76
21	7	34.9	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.71
21	8	34.8	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.67
21	9	34.7	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.62
21	10	34.6	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.58
21	11	34.5	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.53
21	12	34.4	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.49
21	13	34.3	0.09	0.22	0.01	0.56	0.05	0.11	0.16	35.44
21	14	34.2	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.4
21	15	34.1	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.35
21	16	34	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.31
21	17	33.9	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.26
21	18	33.8	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.22
21	19	33.7	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.17
22	1	33.6	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.13
22	2	33.5	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.08
22	3	33.4	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35.04
22	4	33.3	0.08	0.22	0.01	0.56	0.05	0.11	0.16	35
22	5	33.2	0.08	0.22	0.01	0.56	0.05	0.11	0.16	34.95
22	6	33.1	0.08	0.22	0.01	0.56	0.05	0.11	0.16	34.91
22	7	33	0.08	0.22	0.01	0.56	0.05	0.11	0.16	34.86
22	8	32.9	0.08	0.22	0.01	0.56	0.04	0.11	0.16	34.82
22	9	32.8	0.08	0.22	0.01	0.56	0.04	0.11	0.16	34.77
22	10	32.7	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.73
22	11	32.6	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.69
22	12	32.5	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.64
22	13	32.4	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.6

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
22	14	32.3	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.56
22	15	32.2	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.51
22	16	32.1	0.08	0.22	0.01	0.56	0.04	0.12	0.16	34.47
22	17	32	0.07	0.22	0.01	0.56	0.04	0.12	0.16	34.43
22	18	31.9	0.07	0.22	0.01	0.56	0.04	0.12	0.16	34.38
22	19	31.8	0.07	0.22	0.01	0.56	0.04	0.12	0.16	34.34
23	1	31.7	0.07	0.22	0.01	0.56	0.04	0.12	0.16	34.3
23	2	31.6	0.07	0.22	0.01	0.56	0.04	0.12	0.16	34.25
23	3	31.5	0.07	0.22	0.01	0.56	0.04	0.12	0.16	34.21
23	4	31.4	0.07	0.22	0.01	0.57	0.04	0.12	0.16	34.16
23	5	31.3	0.07	0.22	0.01	0.57	0.04	0.12	0.16	34.11
23	6	31.2	0.07	0.22	0.01	0.57	0.04	0.12	0.16	34.03
24	1	31.1	0.07	0.21	0.01	0.57	0.04	0.12	0.16	33.85
24	2	31	0.07	0.21	0.01	0.56	0.04	0.12	0.16	33.67
26	1	30.9	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.89
26	2	30.8	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.78
26	3	30.7	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.67
26	4	30.6	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.56
26	5	30.5	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.45
26	6	30.4	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.33
27	1	30.3	0.07	0.21	0.01	0.55	0.04	0.11	0.15	32.21
27	2	30.2	0.07	0.21	0.01	0.55	0.04	0.12	0.15	32.1
27	3	30.1	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.98
27	4	30	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.87
27	5	29.9	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.76
27	6	29.8	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.65
27	7	29.7	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.54
27	8	29.6	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.43
27	9	29.5	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.32
27	10	29.4	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.21
27	11	29.3	0.07	0.21	0.01	0.55	0.04	0.12	0.15	31.1
27	12	29.2	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.99
27	13	29.1	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.88
27	14	29	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.77
27	15	28.9	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.67
27	16	28.8	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.56
28	1	28.7	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.49
28	2	28.6	0.07	0.21	0.01	0.55	0.04	0.12	0.15	30.4
28	3	28.5	0.06	0.21	0.01	0.55	0.04	0.12	0.15	30.31
28	4	28.4	0.06	0.21	0.01	0.55	0.04	0.12	0.15	30.21
28	5	28.3	0.06	0.21	0.01	0.55	0.04	0.12	0.15	30.12
28	6	28.2	0.06	0.21	0.01	0.55	0.04	0.12	0.15	30.03
28	7	28.1	0.06	0.21	0.01	0.55	0.04	0.12	0.15	29.94
28	8	28	0.06	0.21	0.01	0.55	0.04	0.12	0.15	29.85
28	9	27.9	0.06	0.21	0.01	0.55	0.04	0.12	0.15	29.76
28	10	27.8	0.06	0.21	0.01	0.56	0.04	0.12	0.15	29.67

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
28	11	27.7	0.06	0.21	0.01	0.56	0.04	0.12	0.15	29.58
28	12	27.6	0.06	0.21	0.01	0.56	0.04	0.12	0.15	29.49
28	13	27.5	0.06	0.21	0.01	0.56	0.04	0.12	0.15	29.4
28	14	27.4	0.06	0.21	0.01	0.56	0.04	0.12	0.15	29.31
28	15	27.3	0.06	0.21	0.01	0.56	0.03	0.12	0.15	29.23
28	16	27.2	0.06	0.21	0.01	0.56	0.03	0.12	0.15	29.14
28	17	27.1	0.06	0.21	0.01	0.56	0.03	0.12	0.15	29.08
28	18	27	0.06	0.21	0.01	0.56	0.03	0.12	0.15	29.17
28	19	26.9	0.06	0.2	0.01	0.56	0.04	0.12	0.15	30.35
30	1	26.8	0.07	0.19	0.01	0.61	0.05	0.1	0.15	39.47
30	2	26.7	0.07	0.19	0.01	0.62	0.05	0.1	0.15	39.36
30	3	26.6	0.07	0.19	0.01	0.63	0.05	0.1	0.15	39.26
30	4	26.5	0.07	0.19	0.01	0.63	0.05	0.1	0.15	39.16
30	5	26.4	0.07	0.19	0.01	0.64	0.05	0.1	0.15	39.05
30	6	26.3	0.07	0.19	0.01	0.65	0.05	0.1	0.15	38.95
30	7	26.2	0.07	0.18	0.01	0.66	0.05	0.1	0.15	38.85
30	8	26.1	0.06	0.18	0.01	0.66	0.05	0.1	0.15	38.75
30	9	26	0.06	0.18	0.01	0.67	0.04	0.1	0.15	38.65
30	10	25.9	0.06	0.18	0.01	0.68	0.04	0.1	0.15	38.55
30	11	25.8	0.06	0.18	0.01	0.68	0.04	0.1	0.15	38.46
30	12	25.7	0.06	0.18	0.01	0.69	0.04	0.1	0.15	38.36
30	13	25.6	0.06	0.18	0.01	0.7	0.04	0.1	0.15	38.27
30	14	25.5	0.06	0.18	0.01	0.71	0.04	0.1	0.15	38.17
30	15	25.4	0.06	0.18	0.01	0.71	0.04	0.1	0.15	38.08
30	16	25.3	0.06	0.18	0.01	0.72	0.04	0.1	0.15	37.99
30	17	25.2	0.06	0.18	0.01	0.73	0.04	0.1	0.15	37.89
30	18	25.1	0.06	0.18	0.01	0.73	0.04	0.1	0.14	37.8
30	19	25	0.06	0.18	0.01	0.74	0.04	0.1	0.14	37.71
31	1	24.9	0.05	0.18	0.01	0.75	0.04	0.1	0.14	37.62
31	2	24.8	0.05	0.17	0.01	0.75	0.04	0.1	0.14	37.54
31	3	24.7	0.05	0.17	0.01	0.76	0.04	0.1	0.14	37.45
31	4	24.6	0.05	0.17	0.01	0.77	0.04	0.1	0.14	37.36
31	5	24.5	0.05	0.17	0.01	0.77	0.04	0.1	0.14	37.28
31	6	24.4	0.05	0.17	0.01	0.78	0.04	0.1	0.14	37.19
31	7	24.3	0.05	0.17	0.01	0.79	0.04	0.1	0.14	37.11
31	8	24.2	0.05	0.17	0.01	0.79	0.04	0.1	0.14	37.02
31	9	24.1	0.05	0.17	0.01	0.8	0.04	0.1	0.14	36.94
31	10	24	0.05	0.17	0.01	0.8	0.03	0.1	0.14	36.86
31	11	23.9	0.05	0.17	0.01	0.81	0.03	0.1	0.14	36.78
31	12	23.8	0.05	0.17	0.01	0.82	0.03	0.1	0.14	36.69
31	13	23.7	0.05	0.17	0.01	0.82	0.03	0.1	0.14	36.61
31	14	23.6	0.05	0.17	0.01	0.83	0.03	0.1	0.14	36.54
31	15	23.5	0.05	0.17	0.01	0.84	0.03	0.1	0.14	36.46
31	16	23.4	0.05	0.17	0.01	0.84	0.03	0.1	0.14	36.38
31	17	23.3	0.04	0.16	0.01	0.85	0.03	0.1	0.14	36.3
31	18	23.2	0.04	0.16	0.01	0.85	0.03	0.1	0.14	36.21

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
31	19	23.1	0.04	0.16	0.01	0.86	0.03	0.1	0.14	36.09
32	1	23	0.04	0.16	0.01	0.87	0.03	0.1	0.14	35.87
32	2	22.9	0.04	0.16	0.01	0.87	0.03	0.1	0.14	35.74
32	3	22.8	0.04	0.16	0.01	0.88	0.03	0.1	0.13	35.61
32	4	22.7	0.04	0.16	0.01	0.89	0.03	0.1	0.13	35.48
32	5	22.6	0.04	0.16	0.01	0.9	0.03	0.1	0.13	35.35
32	6	22.5	0.04	0.16	0.01	0.9	0.03	0.1	0.13	35.22
32	7	22.4	0.04	0.16	0.01	0.91	0.03	0.1	0.13	35.1
32	8	22.3	0.04	0.16	0.01	0.92	0.03	0.1	0.13	34.97
32	9	22.2	0.04	0.16	0.01	0.92	0.03	0.1	0.13	34.85
32	10	22.1	0.04	0.16	0.01	0.93	0.03	0.1	0.13	34.73
32	11	22	0.04	0.16	0.01	0.94	0.03	0.1	0.13	34.66
32	12	21.9	0.04	0.16	0.01	0.94	0.03	0.1	0.13	34.88
32	13	21.8	0.04	0.16	0.01	0.95	0.03	0.1	0.13	37.19
32	14	21.7	0.04	0.16	0.01	0.97	0.03	0.12	0.15	54.29
32	15	21.6	0.04	0.15	0.01	1	0.04	0.19	0.23	168.65
33	1	21.5	0.03	0.14	0.01	1.18	0.06	0.73	0.79	973.92
33	2	21.4	0.03	0.13	0.01	1.33	0.08	1.14	1.23	1603.3
33	3	21.3	0.03	0.12	0.01	1.44	0.1	1.48	1.58	2050
33	4	21.2	0.03	0.12	0.01	1.54	0.11	1.75	1.86	2050
33	5	21.1	0.02	0.11	0.01	1.61	0.12	1.94	2.07	2050
34	1	21	0.03	0.12	0.01	1.66	0.12	1.92	2.04	2050
34	2	20.9	0.04	0.15	0.01	1.76	0.13	1.88	2.01	2050
34	3	20.8	0.05	0.2	0.01	1.97	0.15	1.83	1.98	2050
34	4	20.7	0.09	0.32	0.01	2.42	0.18	1.76	1.94	2050
34	5	20.6	0.1	0.32	0.01	2.43	0.18	1.73	1.91	2050
35	1	20.5	0.11	0.31	0.01	2.43	0.17	1.7	1.87	1250
35	2	20.4	0.12	0.32	0.01	2.45	0.17	1.67	1.84	1250
35	3	20.3	0.13	0.32	0.01	2.48	0.17	1.65	1.81	1250
35	4	20.2	0.14	0.34	0.01	2.56	0.17	1.63	1.79	1250
35	5	20.1	0.17	0.39	0.01	2.76	0.17	1.62	1.79	1250
35	6	20	0.18	0.38	0.01	2.75	0.17	1.6	1.76	1250
35	7	19.9	0.18	0.38	0.01	2.74	0.16	1.57	1.74	1250
35	8	19.8	0.19	0.37	0.01	2.74	0.16	1.55	1.71	1250
35	9	19.7	0.19	0.37	0.01	2.73	0.16	1.53	1.69	1250
35	10	19.6	0.2	0.37	0.01	2.73	0.15	1.51	1.66	1250
35	11	19.5	0.2	0.37	0.01	2.72	0.15	1.49	1.64	1250
35	12	19.4	0.2	0.36	0.01	2.72	0.15	1.46	1.61	1250
35	13	19.3	0.2	0.36	0.01	2.71	0.14	1.44	1.58	1250
36	1	19.2	0.2	0.35	0.01	2.71	0.14	1.41	1.55	1250
36	2	19.1	0.2	0.34	0.01	2.71	0.14	1.38	1.52	1224.2
36	3	19	0.19	0.34	0.01	2.71	0.13	1.35	1.48	1197.1
36	4	18.9	0.19	0.33	0.01	2.71	0.13	1.32	1.45	1167.8
37	1	18.8	0.18	0.32	0.01	2.71	0.13	1.28	1.41	1132.2
37	2	18.7	0.18	0.31	0.01	2.71	0.12	1.24	1.36	1096.4
37	3	18.6	0.17	0.3	0.01	2.7	0.12	1.2	1.31	1057.5

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
37	4	18.5	0.17	0.29	0.01	2.68	0.11	1.14	1.25	1008.6
37	5	18.4	0.17	0.27	0.01	2.62	0.11	1.06	1.16	933.83
37	6	18.3	0.17	0.27	0.01	2.63	0.1	1.03	1.14	912.52
37	7	18.2	0.16	0.26	0.01	2.63	0.1	1.01	1.11	892.53
37	8	18.1	0.16	0.26	0.01	2.63	0.1	0.99	1.09	874.24
37	9	18	0.16	0.25	0.01	2.64	0.1	0.97	1.07	858.58
37	10	17.9	0.15	0.25	0.01	2.64	0.1	0.96	1.06	847.89
38	1	17.8	0.15	0.25	0.01	2.64	0.1	0.96	1.06	847.74
38	2	17.7	0.15	0.25	0.01	2.63	0.1	0.96	1.05	847.6
38	3	17.6	0.15	0.25	0.01	2.63	0.09	0.96	1.05	847.39
38	4	17.5	0.15	0.25	0.01	2.63	0.09	0.96	1.05	847.19
38	5	17.4	0.15	0.25	0.01	2.62	0.09	0.96	1.05	846.98
38	6	17.3	0.15	0.25	0.01	2.62	0.09	0.96	1.05	846.77
38	7	17.2	0.15	0.25	0.01	2.61	0.09	0.96	1.05	846.56
38	8	17.1	0.15	0.25	0.01	2.61	0.09	0.96	1.05	846.35
38	9	17	0.15	0.25	0.01	2.6	0.09	0.96	1.05	846.14
38	10	16.9	0.15	0.25	0.01	2.6	0.09	0.96	1.05	845.93
38	11	16.8	0.15	0.25	0.01	2.59	0.09	0.96	1.04	845.71
38	12	16.7	0.15	0.25	0.01	2.59	0.09	0.96	1.04	845.5
38	13	16.6	0.15	0.24	0.01	2.59	0.09	0.96	1.04	845.29
38	14	16.5	0.15	0.24	0.01	2.58	0.09	0.95	1.04	845.07
38	15	16.4	0.15	0.24	0.01	2.58	0.09	0.95	1.04	844.86
38	16	16.3	0.15	0.24	0.01	2.57	0.09	0.95	1.04	844.64
38	17	16.2	0.15	0.24	0.01	2.57	0.08	0.95	1.04	844.43
38	18	16.1	0.15	0.24	0.01	2.56	0.08	0.95	1.04	844.21
39	1	16	0.15	0.24	0.01	2.56	0.08	0.95	1.04	843.99
39	2	15.9	0.15	0.24	0.01	2.56	0.08	0.95	1.03	843.78
39	3	15.8	0.15	0.24	0.01	2.55	0.08	0.95	1.03	843.56
39	4	15.7	0.15	0.24	0.01	2.55	0.08	0.95	1.03	843.34
39	5	15.6	0.15	0.24	0.01	2.54	0.08	0.95	1.03	843.12
39	6	15.5	0.15	0.24	0.01	2.54	0.08	0.95	1.03	842.9
39	7	15.4	0.15	0.24	0.01	2.54	0.08	0.95	1.03	842.68
39	8	15.3	0.15	0.24	0.01	2.53	0.08	0.95	1.03	842.46
39	9	15.2	0.15	0.24	0.01	2.53	0.08	0.95	1.03	842.24
39	10	15.1	0.15	0.24	0.01	2.52	0.08	0.95	1.03	842.02
39	11	15	0.15	0.24	0.01	2.52	0.08	0.95	1.03	841.8
39	12	14.9	0.15	0.24	0.01	2.51	0.08	0.95	1.02	841.57
40	1	14.8	0.15	0.24	0.01	2.51	0.08	0.95	1.02	841.34
40	2	14.7	0.15	0.24	0.01	2.51	0.07	0.95	1.02	841.1
40	3	14.6	0.15	0.24	0.02	2.5	0.07	0.95	1.02	840.84
40	4	14.5	0.15	0.24	0.02	2.5	0.07	0.95	1.02	840.52
40	5	14.4	0.15	0.24	0.02	2.49	0.07	0.95	1.02	840.08
40	6	14.3	0.15	0.24	0.02	2.49	0.07	0.94	1.02	839.34
40	7	14.2	0.15	0.23	0.02	2.48	0.07	0.94	1.01	837.91
40	8	14.1	0.15	0.23	0.02	2.47	0.07	0.94	1.01	834.83
40	9	14	0.15	0.23	0.01	2.44	0.07	0.93	1	827.91

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
40	10	13.9	0.15	0.23	0.01	2.39	0.07	0.91	0.98	811.93
40	11	13.8	0.14	0.22	0.01	2.28	0.06	0.87	0.93	774.66
40	12	13.7	0.13	0.19	0.01	2.02	0.06	0.77	0.83	687.28
40	13	13.6	0.09	0.13	0.01	1.41	0.04	0.54	0.58	482.1
Marsh Creek										
2	1	1.8	0.39	0.1	0	0.33	0.09	0.03	0.12	46.55
2	2	1.7	0.39	0.1	0	0.33	0.09	0.03	0.12	46.54
2	3	1.6	0.38	0.1	0	0.33	0.09	0.03	0.12	46.54
2	4	1.5	0.38	0.1	0	0.33	0.09	0.03	0.12	46.53
2	5	1.4	0.38	0.1	0	0.33	0.09	0.03	0.12	46.53
2	6	1.3	0.38	0.1	0	0.33	0.09	0.03	0.12	46.53
2	7	1.2	0.38	0.1	0	0.33	0.09	0.03	0.12	46.53
2	8	1.1	0.38	0.1	0	0.33	0.09	0.03	0.12	46.53
2	9	1	0.37	0.1	0	0.33	0.09	0.03	0.12	46.53
2	10	0.9	0.37	0.1	0	0.33	0.09	0.03	0.12	46.54
2	11	0.8	0.37	0.11	0	0.33	0.09	0.03	0.12	46.56
2	12	0.7	0.37	0.11	0	0.33	0.08	0.03	0.12	46.6
2	13	0.6	0.36	0.11	0	0.33	0.08	0.03	0.12	46.67
2	14	0.5	0.36	0.11	0	0.34	0.08	0.03	0.12	46.81
2	15	0.4	0.36	0.11	0	0.34	0.08	0.03	0.12	47.07
2	16	0.3	0.35	0.11	0	0.35	0.08	0.04	0.12	47.55
2	17	0.2	0.34	0.11	0	0.37	0.08	0.04	0.12	48.45
2	18	0.1	0.33	0.11	0	0.4	0.09	0.04	0.12	50.1
Rapid Creek										
4	1	2.4	0.54	0.02	0	1	0.13	0.05	0.18	34.8
4	2	2.3	0.42	0.03	0	1.34	0.09	0.05	0.14	29.54
4	3	2.2	0.42	0.03	0	1.34	0.09	0.05	0.14	29.47
4	4	2.1	0.42	0.03	0	1.34	0.09	0.05	0.14	29.4
4	5	2	0.42	0.03	0	1.34	0.09	0.05	0.14	29.32
4	6	1.9	0.42	0.03	0	1.34	0.09	0.05	0.14	29.25
4	7	1.8	0.42	0.03	0	1.34	0.09	0.05	0.15	29.18
4	8	1.7	0.42	0.03	0	1.34	0.09	0.05	0.15	29.11
4	9	1.6	0.42	0.03	0	1.34	0.09	0.05	0.15	29.04
4	10	1.5	0.42	0.03	0	1.34	0.09	0.05	0.15	28.97
4	11	1.4	0.42	0.03	0	1.34	0.09	0.06	0.15	28.9
4	12	1.3	0.42	0.03	0	1.34	0.09	0.06	0.15	28.83
5	1	1.2	0.42	0.03	0	1.34	0.09	0.06	0.15	28.76
5	2	1.1	0.42	0.03	0	1.34	0.09	0.06	0.15	28.69
5	3	1	0.41	0.03	0	1.34	0.09	0.06	0.15	28.61
5	4	0.9	0.41	0.03	0	1.34	0.09	0.06	0.15	28.54
5	5	0.8	0.41	0.03	0	1.34	0.09	0.06	0.15	28.48
5	6	0.7	0.41	0.03	0	1.34	0.09	0.06	0.15	28.41
5	7	0.6	0.41	0.03	0	1.34	0.09	0.06	0.15	28.34
5	8	0.5	0.41	0.03	0	1.34	0.09	0.06	0.15	28.27

APPENDIX F (continued)

Reach Number	Element Number	River Distance (km)	ON_N (mg/L)	NH4_N (mg/L)	NO2_N (mg/L)	NO3_N (mg/L)	ORG_P (mg/L)	DIS_P (mg/L)	TOT_P (mg/L)	Chl a (ug/L)
5	9	0.4	0.41	0.03	0	1.34	0.09	0.06	0.15	28.2
5	10	0.3	0.41	0.03	0	1.34	0.09	0.06	0.15	28.13
5	11	0.2	0.41	0.03	0	1.33	0.09	0.06	0.15	28.06
5	12	0.1	0.44	0.04	0	1.27	0.09	0.06	0.15	28.01
Indian Creek										
7	1	0.8	0.36	0.03	0	1.6	0.25	0.04	0.29	50.67
7	2	0.7	0.36	0.03	0	1.6	0.25	0.04	0.29	49.81
7	3	0.6	0.36	0.03	0	1.6	0.25	0.04	0.29	48.95
7	4	0.5	0.36	0.03	0	1.6	0.25	0.04	0.29	48.11
7	5	0.4	0.36	0.03	0	1.6	0.25	0.04	0.29	47.29
7	6	0.3	0.36	0.03	0	1.6	0.25	0.04	0.29	46.47
7	7	0.2	0.36	0.03	0	1.6	0.25	0.04	0.29	45.65
7	8	0.1	0.37	0.03	0	1.56	0.25	0.04	0.29	44.3
Mink Creek										
14	1	0.2	0.6	0.89	0	0.09	0.24	0.33	0.58	88.44
14	2	0.1	0.59	0.84	0	0.13	0.23	0.32	0.55	84.14
Gibson Jack Creek										
17	1	0.2	0.6	0.89	0	0	0.02	0.02	0.05	12.22
17	2	0.1	0.59	0.84	0	0.05	0.03	0.03	0.06	14.15
Johnny Creek										
19	1	0.2	0.6	0.9	0	0.01	0.02	0.02	0.05	11.81
19	2	0.1	0.59	0.87	0	0.03	0.03	0.03	0.06	12.34
City Creek										
25	1	0.2	0.6	0.9	0	0.09	0.02	0.01	0.03	8.4
25	2	0.1	0.59	0.87	0	0.12	0.02	0.02	0.04	9.6
Pocatello Creek										
29	1	0.7	0.81	0.05	0	1.69	0.09	0.07	0.16	32.23
29	2	0.6	0.81	0.05	0	1.69	0.09	0.07	0.16	32.21
29	3	0.5	0.81	0.05	0	1.69	0.09	0.07	0.16	32.2
29	4	0.4	0.81	0.05	0	1.69	0.09	0.07	0.16	32.18
29	5	0.3	0.81	0.05	0	1.69	0.09	0.07	0.16	32.15
29	6	0.2	0.8	0.05	0	1.67	0.09	0.07	0.16	32.08
29	7	0.1	0.76	0.07	0	1.57	0.09	0.07	0.17	31.79

APPENDIX G Output Data and Input Variables of Monte Carlo Simulation

MONTE CARLO SIMULATION SUMMARY, RESPONSE NO. 15 DO

STATISTIC	LOCATION				
	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5
BASE MEAN	7.748	8.22	8.097	8.198	8.301
SIM MEAN	7.744	8.218	8.114	8.245	8.394
BIAS	-0.004	-0.002	0.017	0.047	0.093
MINIMUM	6.663	7.121	7.43	7.312	7.049
MAXIMUM	8.729	9.176	8.861	9.499	10.482
RANGE	2.066	2.055	1.431	2.187	3.432
STD DEV	0.291	0.265	0.197	0.292	0.455
COEF VAR	0.038	0.032	0.024	0.035	0.054
SKEW COEF	-0.132	-0.192	0.075	0.333	0.539

FREQUENCY

DISTRIBUTION

(STDV FROM MEAN)

	CUM REL		CUM REL		CUM REL		CUM REL		CUM REL	
	FREQ	FREQ								
LT -4.0	0	0	1	0	0	0	0	0	0	0
-4.0 TO -3.5	4	0.001	2	0.001	0	0	0	0	0	0
-3.5 TO -3.0	10	0.003	9	0.002	4	0.001	2	0	0	0
-3.0 TO -2.5	24	0.008	29	0.008	18	0.004	7	0.002	5	0.001
-2.5 TO -2.0	90	0.026	110	0.03	85	0.021	55	0.013	41	0.009
-2.0 TO -1.5	227	0.071	213	0.073	224	0.066	222	0.057	193	0.048
-1.5 TO -1.0	442	0.159	443	0.161	452	0.157	480	0.153	508	0.149
-1.0 TO -0.5	707	0.301	674	0.296	788	0.314	844	0.322	869	0.323
-0.5 TO 0.0	936	0.488	937	0.484	952	0.505	1028	0.528	1105	0.544
0.0 TO 0.5	969	0.682	997	0.683	943	0.693	879	0.703	848	0.714
0.5 TO 1.0	812	0.844	781	0.839	745	0.842	693	0.842	661	0.846
1.0 TO 1.5	468	0.938	507	0.941	438	0.93	427	0.927	385	0.923
1.5 TO 2.0	214	0.981	209	0.982	228	0.975	209	0.969	214	0.966
2.0 TO 2.5	77	0.996	74	0.997	91	0.994	95	0.988	96	0.985
2.5 TO 3.0	15	0.999	11	0.999	21	0.998	37	0.996	39	0.993
3.0 TO 3.5	5	1	2	1	10	1	15	0.999	23	0.997
3.5 TO 4.0	0	1	1	1	1	1	5	1	9	0.999
GT +4.0	0	1	0	1	0	1	2	1	4	1

APPENDIX G (continued)

MONTE CARLO SIMULATION SUMMARY, RESPONSE NO. 18 NH3N

LOCATION

STATISTIC

	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5
BASE MEAN	0.116	0.219	0.32	0.385	0.273
SIM MEAN	0.116	0.219	0.32	0.385	0.272
BIAS	0	0	0	0	-0.001
MINIMUM	0.082	0.15	0.247	0.295	0.208
MAXIMUM	0.159	0.293	0.425	0.514	0.372
RANGE	0.077	0.143	0.178	0.219	0.164
STD DEV	0.011	0.02	0.025	0.031	0.022
COEF VAR	0.091	0.092	0.077	0.081	0.08
SKEW COEF	0.276	0.235	0.316	0.333	0.281

FREQUENCY

DISTRIBUTION

(STDV FROM MEAN)

	CUM REL	CUM REL	CUM REL	CUM REL	CUM REL
	FREQ	FREQ	FREQ	FREQ	FREQ
LT -4.0	0	0	0	0	0
-4.0 TO -3.5	0	0	0	0	0
-3.5 TO -3.0	2	0	5	0.001	0
-3.0 TO -2.5	12	0.003	15	0.004	15
-2.5 TO -2.0	55	0.014	61	0.016	51
-2.0 TO -1.5	209	0.056	200	0.056	205
-1.5 TO -1.0	531	0.162	503	0.157	547
-1.0 TO -0.5	801	0.322	817	0.32	778
-0.5 TO 0.0	975	0.517	951	0.51	989
0.0 TO 0.5	951	0.707	950	0.7	966
0.5 TO 1.0	668	0.841	710	0.842	651
1.0 TO 1.5	435	0.928	415	0.925	440
1.5 TO 2.0	201	0.968	221	0.97	208
2.0 TO 2.5	109	0.99	105	0.991	86
2.5 TO 3.0	32	0.996	32	0.997	48
3.0 TO 3.5	17	1	13	1	9
3.5 TO 4.0	1	1	2	1	5
GT +4.0	1	1	0	1	2
					1
					1
					1
					1

APPENDIX G (continued)

MONTE CARLO SIMULATION SUMMARY, RESPONSE NO. 20 NO3N

STATISTIC	LOCATION				
	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5
BASE MEAN	0.468	0.556	2.425	2.758	2.622
SIM MEAN	0.469	0.555	2.423	2.755	2.617
BIAS	0.001	-0	-0	-0	-0.01
MINIMUM	0.365	0.435	1.762	2.058	1.82
MAXIMUM	0.595	0.673	3.425	3.834	3.821
RANGE	0.231	0.238	1.663	1.776	2.001
STD DEV	0.033	0.031	0.224	0.234	0.265
COEF VAR	0.071	0.055	0.092	0.085	0.101
SKEW COEF	0.228	0.119	0.377	0.327	0.393

FREQUENCY

DISTRIBUTION

(STDV FROM MEAN)

	CUM REL		CUM REL		CUM REL		CUM REL		CUM REL	
	FREQ	FREQ								
LT -4.0	0	0	0	0	0	0	0	0	0	0
-4.0 TO -3.5	0	0	1	0	0	0	0	0	0	0
-3.5 TO -3.0	2	0	3	0.001	0	0	0	0	1	0
-3.0 TO -2.5	12	0.003	17	0.004	10	0.002	13	0.003	6	0.001
-2.5 TO -2.0	64	0.016	68	0.018	55	0.013	60	0.015	58	0.013
-2.0 TO -1.5	215	0.059	240	0.066	203	0.054	201	0.055	210	0.055
-1.5 TO -1.0	516	0.162	454	0.157	513	0.156	504	0.156	493	0.154
-1.0 TO -0.5	785	0.319	781	0.313	827	0.322	832	0.322	838	0.321
-0.5 TO 0.0	1024	0.524	1008	0.514	1023	0.526	1004	0.523	1053	0.532
0.0 TO 0.5	851	0.694	892	0.693	887	0.704	904	0.704	870	0.706
0.5 TO 1.0	723	0.838	740	0.841	713	0.846	709	0.845	708	0.847
1.0 TO 1.5	440	0.926	426	0.926	412	0.929	422	0.93	404	0.928
1.5 TO 2.0	238	0.974	253	0.977	193	0.967	202	0.97	195	0.967
2.0 TO 2.5	80	0.99	81	0.993	96	0.986	88	0.988	96	0.986
2.5 TO 3.0	37	0.997	23	0.997	46	0.996	43	0.996	48	0.996
3.0 TO 3.5	10	0.999	10	0.999	13	0.998	11	0.999	9	0.998
3.5 TO 4.0	3	1	3	1	7	1	5	1	8	0.999
GT +4.0	0	1	0	1	2	1	2	1	3	1

APPENDIX G (continued)

MONTE CARLO SIMULATION SUMMARY, RESPONSE NO. 24 SUMP

STATISTIC	LOCATION				
	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5
BASE MEAN	0.125	0.162	1.936	1.793	1.164
SIM MEAN	0.126	0.163	1.938	1.794	1.164
BIAS	0.001	0	0.002	0.001	0
MINIMUM	0.073	0.112	1.125	1.108	0.719
MAXIMUM	0.241	0.267	3.903	3.445	2.236
RANGE	0.167	0.155	2.778	2.337	1.517
STD DEV	0.023	0.02	0.346	0.283	0.185
COEF VAR	0.183	0.125	0.179	0.158	0.159
SKEW COEF	0.686	0.628	0.681	0.671	0.673

FREQUENCY

DISTRIBUTION

(STDV FROM MEAN)

	CUM REL		CUM REL		CUM REL		CUM REL		CUM REL	
	FREQ	FREQ								
LT -4.0	0	0	0	0	0	0	0	0	0	0
-4.0 TO -3.5	0	0	0	0	0	0	0	0	0	0
-3.5 TO -3.0	0	0	0	0	0	0	0	0	0	0
-3.0 TO -2.5	0	0	0	0	0	0	0	0	0	0
-2.5 TO -2.0	20	0.004	36	0.007	29	0.006	32	0.006	31	0.006
-2.0 TO -1.5	179	0.04	183	0.044	192	0.044	195	0.045	199	0.046
-1.5 TO -1.0	569	0.154	521	0.148	531	0.15	512	0.148	507	0.147
-1.0 TO -0.5	906	0.335	947	0.337	894	0.329	899	0.328	900	0.327
-0.5 TO 0.0	1045	0.544	1014	0.54	1045	0.538	1058	0.539	1051	0.538
0.0 TO 0.5	900	0.724	913	0.723	923	0.723	923	0.724	928	0.723
0.5 TO 1.0	602	0.844	609	0.845	641	0.851	625	0.849	620	0.847
1.0 TO 1.5	392	0.923	396	0.924	366	0.924	370	0.923	381	0.923
1.5 TO 2.0	199	0.962	201	0.964	194	0.963	200	0.963	199	0.963
2.0 TO 2.5	99	0.982	102	0.984	104	0.984	108	0.984	104	0.984
2.5 TO 3.0	51	0.992	38	0.992	43	0.992	40	0.992	40	0.992
3.0 TO 3.5	23	0.997	25	0.997	18	0.996	20	0.996	22	0.996
3.5 TO 4.0	9	0.999	10	0.999	11	0.998	9	0.998	8	0.998
GT +4.0	6	1	5	1	9	1	9	1	10	1

APPENDIX G (continued)

MONTE CARLO SIMULATION SUMMARY, RESPONSE NO. 25 CHLA

STATISTIC	LOCATION					
	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	
BASE MEAN	1.272	0.874	50	50	37.34	
SIM MEAN	1.321	0.908	48.9	48.61	38.29	
BIAS	0.049	0.034	-1.1	-1.39	0.951	
MINIMUM	0.613	0.38	26.97	26.12	16.92	
MAXIMUM	2.552	1.816	50	50	50	
RANGE	1.939	1.436	23.03	23.88	33.08	
STD DEV	0.27	0.202	2.954	3.299	7.546	
COEF VAR	0.204	0.223	0.06	0.068	0.197	
SKEW COEF	0.566	0.592	-3.2	-2.76	-0.03	

FREQUENCY

DISTRIBUTION

(STDV FROM MEAN)

	CUM REL		CUM REL		CUM REL		CUM REL		CUM REL	
	FREQ	FREQ								
LT -4.0	0	0	0	0	67	0.013	57	0.011	0	0
-4.0 TO -3.5	0	0	0	0	47	0.023	42	0.02	0	0
-3.5 TO -3.0	0	0	0	0	40	0.031	54	0.031	0	0
-3.0 TO -2.5	1	0	1	0	89	0.049	79	0.046	5	0.001
-2.5 TO -2.0	30	0.006	35	0.007	83	0.065	106	0.068	62	0.013
-2.0 TO -1.5	187	0.044	191	0.045	97	0.085	137	0.095	268	0.067
-1.5 TO -1.0	538	0.151	527	0.151	128	0.11	148	0.125	556	0.178
-1.0 TO -0.5	930	0.337	913	0.333	136	0.137	180	0.161	791	0.336
-0.5 TO 0.0	998	0.537	1024	0.538	137	0.165	185	0.198	886	0.514
0.0 TO 0.5	911	0.719	905	0.719	4176	1	4012	1	794	0.672
0.5 TO 1.0	626	0.844	647	0.849	0	1	0	1	610	0.794
1.0 TO 1.5	388	0.922	377	0.924	0	1	0	1	405	0.875
1.5 TO 2.0	212	0.964	198	0.964	0	1	0	1	623	1
2.0 TO 2.5	91	0.982	96	0.983	0	1	0	1	0	1
2.5 TO 3.0	57	0.994	54	0.994	0	1	0	1	0	1
3.0 TO 3.5	22	0.998	18	0.997	0	1	0	1	0	1
3.5 TO 4.0	8	1	10	0.999	0	1	0	1	0	1
GT +4.0	1	1	4	1	0	1	0	1	0	1

APPENDIX G (continued)

The method to convert horizontal axis from standard deviations to the actual variable values is that sim mean plus or minus the number of standard deviations times the value of the standard deviation. For example, DO at Reach 3 Element 10,

$$DO = 7.744 + 0.291 \times \frac{(-4.0) + (-3.5)}{2} = 6.65(\text{mg/L})$$

where, 7.744 is the sim mean, 0.291 is the value of the standard deviation (STD DEV), -4.0, and -3.5 are the number of STD DEV.

The method to convert vertical axis from frequency to relative frequency is that the frequency number divides by the total number of iterations (5000).

The conversion results are shown below:

		DO (mg/L)					Relative Frequency				
REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5		
6.58	7.16	7.33	7.08	6.57	0.000	0.000	0.000	0.000	0.000	0.000	0.000
6.65	7.22	7.38	7.15	6.69	0.001	0.000	0.000	0.000	0.000	0.000	0.000
6.80	7.36	7.47	7.30	6.92	0.002	0.002	0.001	0.000	0.000	0.000	0.000
6.94	7.49	7.57	7.44	7.14	0.005	0.006	0.004	0.001	0.001	0.001	0.001
7.09	7.62	7.67	7.59	7.37	0.018	0.022	0.017	0.011	0.008	0.008	0.008
7.23	7.75	7.77	7.73	7.60	0.045	0.043	0.045	0.044	0.039	0.039	0.039
7.38	7.89	7.87	7.88	7.83	0.088	0.089	0.090	0.096	0.102	0.102	0.102
7.53	8.02	7.97	8.03	8.05	0.141	0.135	0.158	0.169	0.174	0.174	0.174
7.67	8.15	8.06	8.17	8.28	0.187	0.187	0.190	0.206	0.221	0.221	0.221
7.82	8.28	8.16	8.32	8.51	0.194	0.199	0.189	0.176	0.170	0.170	0.170
7.96	8.42	8.26	8.46	8.74	0.162	0.156	0.149	0.139	0.132	0.132	0.132
8.11	8.55	8.36	8.61	8.96	0.094	0.101	0.088	0.085	0.077	0.077	0.077
8.25	8.68	8.46	8.76	9.19	0.043	0.042	0.046	0.042	0.043	0.043	0.043
8.40	8.81	8.56	8.90	9.42	0.015	0.015	0.018	0.019	0.019	0.019	0.019
8.54	8.95	8.66	9.05	9.65	0.003	0.002	0.004	0.007	0.008	0.008	0.008
8.69	9.08	8.75	9.19	9.87	0.001	0.000	0.002	0.003	0.005	0.005	0.005
8.84	9.21	8.85	9.34	10.10	0.000	0.000	0.001	0.002	0.002	0.002	0.002
8.91	9.28	8.90	9.41	10.21	0.000	0.000	0.000	0.000	0.001	0.001	0.001

APPENDIX G (continued)

NH4-N (mg/L)												Relative Frequency											
REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5									
0.072	0.139	0.220	0.261	0.184	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
0.075	0.144	0.226	0.269	0.190	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
0.080	0.154	0.239	0.284	0.201	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		
0.086	0.164	0.251	0.300	0.212	0.002	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.002	0.003	0.003	0.003	0.003	0.003	0.003	0.003	0.003		
0.091	0.174	0.264	0.315	0.223	0.011	0.012	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.010	0.013		
0.097	0.184	0.276	0.331	0.234	0.042	0.040	0.041	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.040	0.039	0.039		
0.102	0.194	0.289	0.346	0.245	0.106	0.101	0.109	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.106		
0.108	0.204	0.301	0.362	0.256	0.160	0.163	0.156	0.161	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162	0.162		
0.113	0.214	0.314	0.377	0.267	0.195	0.190	0.198	0.202	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194	0.194		
0.119	0.224	0.326	0.393	0.278	0.190	0.190	0.193	0.185	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183	0.183		
0.124	0.234	0.339	0.408	0.289	0.134	0.142	0.130	0.134	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141	0.141		
0.130	0.244	0.351	0.424	0.300	0.087	0.083	0.088	0.084	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087	0.087		
0.135	0.254	0.364	0.439	0.311	0.040	0.044	0.042	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041	0.041		
0.141	0.264	0.376	0.455	0.322	0.022	0.021	0.017	0.020	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021	0.021		
0.146	0.274	0.389	0.470	0.333	0.006	0.006	0.010	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.008	0.006	0.006		
0.152	0.284	0.401	0.486	0.344	0.003	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002		
0.157	0.294	0.414	0.501	0.355	0.000	0.000	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001		
0.160	0.299	0.420	0.509	0.360	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000		

NO3-N (mg/L)												Relative Frequency											
REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5									
0.34	0.43	1.53	1.82	1.56	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.35	0.44	1.58	1.88	1.62	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.36	0.45	1.70	1.99	1.76	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	
0.38	0.47	1.81	2.11	1.89	0.002	0.003	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.003	0.001	0.001	0.001	
0.39	0.49	1.92	2.23	2.02	0.013	0.014	0.011	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	0.012	
0.41	0.50	2.03	2.35	2.15	0.043	0.048	0.041	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	
0.43	0.52	2.14	2.46	2.29	0.103	0.091	0.103	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.101	0.099	0.099	0.099	0.099	
0.44	0.53	2.26	2.58	2.42	0.157	0.156	0.165	0.166	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	0.168	
0.46	0.55	2.37	2.70	2.55	0.205	0.202	0.205	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.201	0.211	0.211	0.211	0.211	
0.48	0.56	2.48	2.81	2.68	0.170	0.178	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.177	0.174	0.174	0.174	0.174	
0.49	0.58	2.59	2.93	2.82	0.145	0.148	0.143	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	0.142	
0.51	0.59	2.70	3.05	2.95	0.088	0.085	0.082	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.084	0.081	0.081	0.081	0.081	
0.53	0.61	2.82	3.16	3.08	0.048	0.051	0.039	0.040	0.039	0.040	0.039	0.040	0.039	0.040	0.039	0.040	0.039	0.039	0.039	0.039	0.039	0.039	
0.54	0.62	2.93	3.28	3.21	0.016	0.016	0.019	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.018	0.019	0.019	0.019	0.019	
0.56	0.64	3.04	3.40	3.35	0.007	0.005	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.009	0.010	0.010	0.010	0.010	
0.58	0.66	3.15	3.52	3.48	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	0.002	
0.59	0.67	3.26	3.63	3.61	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.002	0.002	0.002	
0.60	0.68	3.32	3.69	3.68	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.001	

APPENDIX G (continued)

		Algae (mg/L)				Relative Frequency					
REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5	REACH 3 ELEMENT 10	REACH 21 ELEMENT 10	REACH 34 ELEMENT 4	REACH 35 ELEMENT 5	REACH 37 ELEMENT 5		
0.24	0.10	37.09	35.42	8.11	0.0000	0.0000	0.0134	0.0114	0.0000		
0.31	0.15	37.83	36.24	10.00	0.0000	0.0000	0.0094	0.0084	0.0000		
0.44	0.25	39.30	37.89	13.77	0.0000	0.0000	0.0080	0.0108	0.0000		
0.58	0.35	40.78	39.54	17.54	0.0002	0.0002	0.0178	0.0158	0.0010		
0.71	0.45	42.26	41.19	21.32	0.0060	0.0070	0.0166	0.0212	0.0124		
0.85	0.55	43.73	42.84	25.09	0.0374	0.0382	0.0194	0.0274	0.0536		
0.98	0.66	45.21	44.49	28.86	0.1076	0.1054	0.0256	0.0296	0.1112		
1.12	0.76	46.69	46.14	32.63	0.1860	0.1826	0.0272	0.0360	0.1582		
1.25	0.86	48.16	47.79	36.41	0.1996	0.2048	0.0274	0.0370	0.1772		
1.39	0.96	49.64	49.44	40.18	0.1822	0.1810	0.8352	0.8024	0.1588		
1.52	1.06	51.12	51.09	43.95	0.1252	0.1294	0.0000	0.0000	0.1220		
1.66	1.16	52.60	52.73	47.73	0.0776	0.0754	0.0000	0.0000	0.0810		
1.79	1.26	54.07	54.38	51.50	0.0424	0.0396	0.0000	0.0000	0.1246		
1.93	1.36	55.55	56.03	55.27	0.0182	0.0192	0.0000	0.0000	0.0000		
2.06	1.46	57.03	57.68	59.05	0.0114	0.0108	0.0000	0.0000	0.0000		
2.20	1.56	58.50	59.33	62.82	0.0044	0.0036	0.0000	0.0000	0.0000		
2.33	1.67	59.98	60.98	66.59	0.0016	0.0020	0.0000	0.0000	0.0000		
2.40	1.72	60.72	61.81	68.48	0.0002	0.0008	0.0000	0.0000	0.0000		

APPENDIX G (continued)

2) Summary of Monte Carlo Input Variance Conditions

No.	INPUT VARIABLE OR PARAMETER	INPUT DATA	RELATIVE STANDARD	INPUT
				TYPE DEVIATION (%) PDF*
1	EVAPORATION COEF - AE	1	10	LN**
2	EVAPORATION COEF - BE	1	10	LN
3	OXYGEN UPTAKE BY NH3 OXDTN	1A	10	LN
4	OXYGEN UPTAKE BY NO2 OXDTN	1A	10	LN
5	OXYGEN PROD BY ALGAE GRWTH	1A	10	LN
6	OXYGEN UPTAKE BY ALGY RESP	1A	10	LN
7	NITROGEN CONTENT OF ALGAE	1A	10	LN
8	PHOSPHORUS CONTENT OF ALGY	1A	10	LN
9	ALGY MAX SPEC GROWTH RATE	1A	10	LN
10	ALGAE RESPIRATION RATE	1A	10	LN
11	NITROGEN HALF SAT'N COEF	1A	10	LN
12	PHOSPHORUS HALF SATN COEF	1A	10	LN
13	LINEAR ALG SELF SHADE COEF	1A	10	LN
14	NON-LIN ALG SELF SHADE CO	1A	10	LN
15	LIGHT SAT'N COEFFICIENT	1A	10	LN
16	LIGHT AVERAGING FACTOR	1A	2	LN
17	ALG PREF FOR AMMONIA-N	1A	10	LN
18	ALG TO TEMP SOLAR FACTOR	1A	1	LN
19	NITRIFICATION INHIB FACT	1A	10	LN
20	5-D TO ULT BOD CONV R-COF	1	10	LN
21	TEMP COEF BOD DECAY	1B	3	LN
22	TEMP COEF BOD SETTLING	1B	3	LN
23	TEMP COEF O2 REAERATION	1B	3	LN
24	TEMP COEF SED O2 DEMAND	1B	3	LN
25	TEMP COEF ORGANIC-N DECAY	1B	3	LN
26	TEMP COEF ORGANIC-N SET	1B	3	LN
27	TEMP COEF AMMONIA DECAY	1B	3	LN
28	TEMP COEF AMMONIA SRCE	1B	3	LN
29	TEMP COEF NITRITE DECAY	1B	3	LN
30	TEMP COEF ORGANIC-P DECAY	1B	3	LN
31	TEMP COEF ORGANIC-P SET	1B	3	LN
32	TEMP COEF DISS-P SOURCE	1B	3	LN
33	TEMP COEF ALGY GROWTH	1B	3	LN
34	TEMP COEF ALGY RESPR	1B	3	LN
35	TEMP COEF ALGY SETTLING	1B	3	LN
36	DISPERSION CORR CONSTANT	5	20	LN
37	COEF ON FLOW FOR VELOCITY	5	8	LN
38	EXPO ON FLOW FOR VELOCITY	5	0.1	LN
39	COEF ON FLOW FOR DEPTH	5	8	LN
40	EXPO ON FLOW FOR DEPTH	5	0.1	LN
41	MANNING'S ROUGHNESS N	5	10	LN
42	MEAN ELEVATION OF REACH	5A	10	LN
43	DUST ATTENUATION COEF	5A	10	LN
44	FRACTION OF CLOUDINESS	5A	13	LN
45	DRY BULB AIR TEMPERATURE	5A	2	LN
46	WET BULB AIR TEMPERATURE	5A	2	LN
47	ATMOSPHERIC PRESSURE	5A	1	LN
48	WIND VELOCITY	5A	15	LN
49	CBOD OXIDATION RATE	6	15	LN
50	CBOD SETTLING RATE	6	15	LN

APPENDIX G (continued)

No.	INPUT VARIABLE OR PARAMETER	INPUT DATA	RELATIVE STANDARD		INPUT
			TYPE	DEVIATION (%)	
51	SOD UPTAKE RATE	6		12	LN
52	ORGANIC-N HYDROLYSIS RATE	6A		20	LN
53	ORGANIC-N SETTLING RATE	6A		15	LN
54	AMMONIA-N DECAY RATE	6A		25	LN
55	AMMONIA-N BENTHAL SOURCE	6A		25	LN
56	NITRITE-N DECAY RATE	6A		20	LN
57	ORGANIC-P HYDROLYSIS RATE	6A		20	LN
58	ORGANIC-P SETTLING RATE	6A		15	LN
59	DISSOLVED-P BENTHAL SRCE	6A		25	LN
60	CHLA TO ALGAE RATIO	6B		20	LN
61	ALGAE SETTLING RATE	6B		15	LN
62	LIGHT EXT COEFFICIENT	6B		5	LN
63	INCREMENTAL FLOW	8		3	LN
64	INCR-TEMPERATURE	8		1	NM***
65	INCR-DISSOLVED OXYGEN	8		3	LN
66	INCR-CONSV MIN 1	8		2	LN
67	INCR-CONSV MIN 2	8		2	LN
68	INCR-ALGAE	8A		13	LN
69	INCR-ORGANIC-N	8A		25	LN
70	INCR-AMMONIA-N	8A		15	LN
71	INCR-NITRATE-N	8A		15	LN
72	INCR-ORGANIC-PHOS	8A		25	LN
73	INCR-DISSOLVED-PHOS	8A		20	LN
74	HEADWATER FLOW	10		3	LN
75	HWTR-TEMPERATURE	10		1	NM
76	HWTR-DISSOLVED OXYGEN	10		3	LN
77	HWTR-BOD	10		15	LN
78	HWTR-CONSV MIN 1	10		4	LN
79	HWTR-CONSV MIN 2	10		4	LN
80	HWTR-ALGAE	10A		4	LN
81	HWTR-ORGANIC-N	10A		6	LN
82	HWTR-AMMONIA-N	10A		10	LN
83	HWTR-NITRATE-N	10A		7	LN
84	HWTR-ORGANIC-PHOS	10A		25	LN
85	HWTR-DISSOLVED-PHOS	10A		7	LN
86	POINT LOAD FLOW	11		3	LN
87	PTLD-TEMPERATURE	11		1	NM
88	PTLD-DISSOLVED OXYGEN	11		3	LN
89	PTLD-BOD	11		15	LN
90	PTLD-CONSV MIN 1	11		4	LN
91	PTLD-CONSV MIN 2	11		4	LN
92	PTLD-ALGAE	11A		13	LN
93	PTLD-ORGANIC-N	11A		1	LN
94	PTLD-AMMONIA-N	11A		10	LN
95	PTLD-NITRATE-N	11A		8	LN
96	PTLD-ORGANIC-PHOS	11A		25	LN
97	PTLD-DISSOLVED-PHOS	11A		14	LN

Note: *PDF: Probability Distribution Function

** LN: Lognormal Distribution

*** NM: Normal Distribution

APPENDIX H

Mass Balance Calculation on Ammonia-N, Nitrate-N and Total Phosphorus in the Lower Portneuf
 (Between River Distance 26.8 km to 17.8 km)

	Reach No.	River	Flow	NH4_N	NO3_N	TOT_P	Waste Load (kg/d)		
		Distance (km)	(m3/s)	(mg/L)	(mg/L)	(mg/L)	NH4_N	NO3_N	TOT_P
Reach 30 Element 1	30	26.8	1.9	0.19	0.61	0.15	31.19	100.14	24.62
FMC Outfall	32	21.6	0.07	0.2	1.26	0.286	1.21	7.62	1.73
WPC Outfall	34	20.6	0.34	3.25	13.02	1.48	95.47	382.48	43.48
Batiste Spring	35	20	0.704	1.09	5.58	2.22	66.30	339.41	135.03
Papoose Spring	37	18.3	0.86	0.08	1.43	0.07	5.94	106.25	5.20
Unidentified Springs	30		0.138	0.05	2.54	0.07	0.59	30.20	0.83
Unidentified Springs	31		0.138	0.05	2.54	0.07	0.59	30.20	0.83
Unidentified Springs	32		0.138	0.05	2.54	0.07	0.59	30.20	0.83
Unidentified Springs	33		1.68	0.05	2.54	4.85	7.26	368.69	703.99
Unidentified Springs	34		0.84	0.22	2.54	1.4	15.97	184.34	101.61
Unidentified Springs	35		1.356	0.22	2.7	0.13	25.77	316.33	15.23
Unidentified Springs	36		0.63	0.05	2.8	0.06	2.72	152.41	3.27
Unidentified Springs	37		2.44	0.05	3	0.06	10.54	632.45	12.65
Reach 37 Element 10	37	17.8	11.234	0.25	2.64	1.06	242.65	2562.43	1028.85